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Honeywell, Inc.
Minneapolis, Minnesota

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and Space Administration

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SECTION 1

SUMMARY

A methodological approach to measuring workload was investigated for evaluation of new concepts in VTOL aircraft displays. Physiological, visual response, and conventional flight performance measures were recorded for landing approaches performed in the NASA Langley Visual Motion Simulator (VMS). Three displays (two computer graphic and a conventional flight director), three crosswind amplitudes, and two motion base conditions (fixed vs. moving base) were tested in a factorial design.

Multivariate discriminant functions were formed from flight performance and/or visual response variables to maximize detection of experimental differences. The flight performance variable discriminant showed maximum differentiation between crosswind conditions. The visual response measure discriminant maximized differences between fixed vs. motion base conditions and experimental displays.

Physiological variables were used to attempt to predict the discriminant function values for each subject/condition trial. The weights of the physiological variables in these equations showed agreement with previous studies. High

muscle tension, light but irregular breathing patterns, and higher heart rate with low amplitude all produced higher scores on this scale and thus, represented higher workload levels.

SECTION 2

INTRODUCTION

Commercial helicopter operations in the next decade will require the ability to perform curved, steep, decelerating instrument landings in small volumes of airspace at crowded terminal areas. Although there will be increased automation of controls and more capable on-board avionics, manual piloting will still be an important requirement. The display systems for these aircraft should present the critical information while requiring the least workload, since the reserve capacity of the pilot will continue to be extremely important for reacting to and handling emergency and fail-op situations.

Critical evaluation of display format alternatives, therefore, should incorporate workload metrics which not only express pilot performance but also express the difficulty with which this performance was achieved. That is, we need to know both how well the pilot performed and how hard it was for him to achieve his measured performance. Previous studies investigating the merit of different display formats have attempted to estimate workload by the use of concurrently performed secondary tasks such as tapping tasks,[1] choice reaction tasks, and number cancelling tasks.[2] This method has not been successful because: 1) primary performances often are not equivalent across conditions, 2) certain secondary and primary tasks interact differently, and 3) the total capacity of the subject is not always used by the secondary task.

Recently, successful measurements of workload have been developed for evaluation of controls and displays in simulation and flight test programs for both

fixed and rotary wing aircraft.[3, 4, 5, 6, 7] This method uses both performance and physiological data to form a metric of information processing workload. The major goal of this study was to explore the potential of this metric for the evaluation of workloads imposed by three candidate VTOL information displays. A second goal was to evaluate the effects of simulator motion and crosswind amplitude on pilot workload.

Conceptual Approach

The landing phase of piloting a VTOL aircraft severely taxes the pilot's information processing and response capabilities. During landing approach, deceleration, and hover, the pilot shares attention between tasks. The overall performance of the system is determined by the difficulty of the tasks involved. Generally, the factors influencing difficulty can be categorized as: 1) information display formats, 2) external forces (that is, wind, visibility), 3) kinesthetic (motion) cues, and 4) pilot experience and skill level. Other items that affect overall performance are the plant dynamics and control force characteristics. In addition, individual pilot variance from mission to mission will affect performance due to fluctuations in fatigue, attention level, and motivational and situational variables.

This study explored the relationship between increasing task demand or difficulty and resultant workload measured in several ways. Conventional flight performance error parameters such as heading, pitch, roll, and power setting are used to evaluate system performance. A relationship between such measures and task difficulty is hypothesized in Figure 1. At very low levels of difficulty, performance error remains at a constant and low level. Increasing difficulty does not impair performance in this region, although workload is increased due to

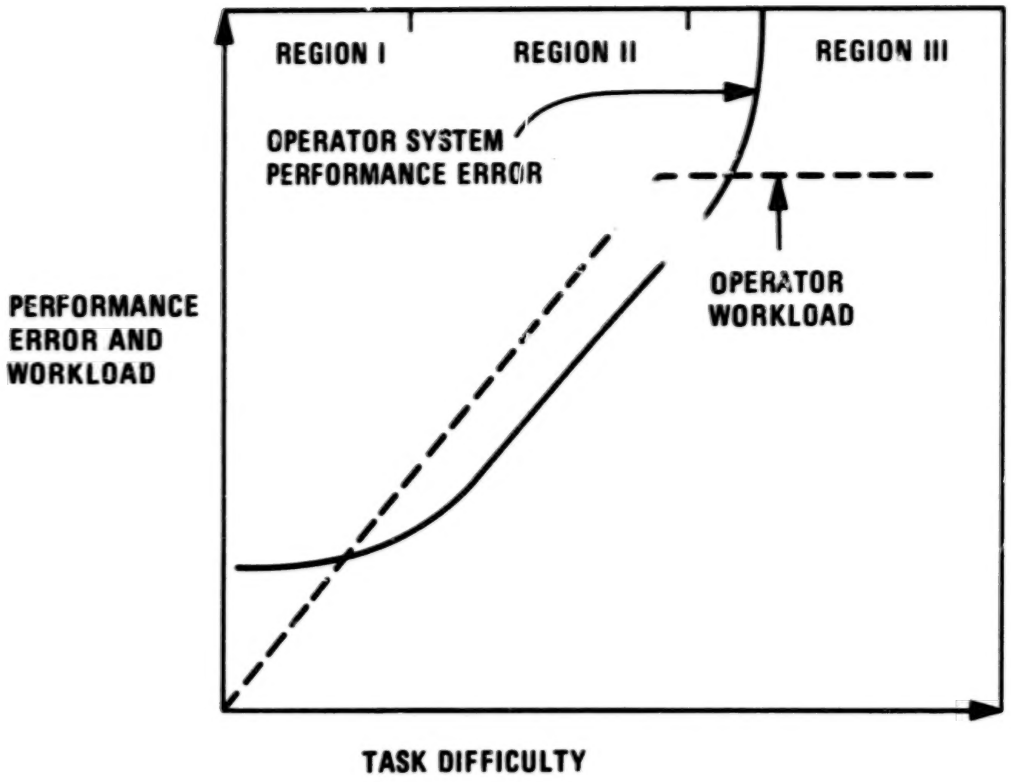

Figure 1. Hypothetical Relationship Between Operator Performance Error and Workload Level Across Increasing Task Difficulty

increasing task difficulty. This is due to the ability of the pilot to compensate for these demands with no resultant performance degradation.

In the next region of task difficulty, performance error and workload are positively correlated. Increased difficulty causes increased performance error. This is analogous to landing approach performance under reduced visibility or high crosswind gust conditions.

In the third region, performance and workload level diverge. Conditions are such that increased difficulty caused by deteriorating operational conditions are beyond the pilot's capability to compensate. Increased performance error continues, but the effective workload on the operator has reached a ceiling. This region is analogous to near complete loss of external visibility during approach or loss of control of a critical flight parameter.

Thus, the relationship between performance error and actual workload is hypothesized as non-linear across increases in task difficulty factors. Conventional flight testing of new display/control concepts are conducted under conditions that often fall in the first region or lower part of the second region described above. The operational environment thus does not always evaluate these systems under high workload or near-worst-case conditions. Furthermore, the conventional measures of flight performance may 1) not be available or 2) be inappropriate for the particular task being evaluated. Terrain following helicopter flight performance, for instance, is not easily measured by conventional flight path error scores.

Experimental Variables

Display Considerations--An analysis of current trends in display design for VTOL cockpits shows emphasis on graphically presented, cathode ray tube (CRT), multifunction displays that combine several important information sources. Such concepts are evident in the Navy's Advanced Integrated Display System (AIDS) and the Air Force's Digital Avionics Information System (DAIS). Similar integrated formats have been evaluated recently for VTOL aircraft.[8]

With the above guidelines in mind, three displays were chosen for evaluation: 1) a CRT graphic display employing a "fly from" guidance principal (GRAPHIC I), 2) a CRT display employing combinations of "fly from" and "fly to" principles (GRAPHIC II), and 3) a conventional flight director. The GRAPHIC I display was expected to require the least amount of workload, while the GRAPHIC II display was expected to require the greatest workload. The flight director was estimated to be an intermediate workload condition. These estimates were based on pilot opinion. A preliminary experiment was conducted to verify these estimations.

Crosswind Effects--Helicopter approach to landing performance has been shown to be a function of the amplitude and deviation of crosswind.[9] Increases in mean wind and gust amplitude were evaluated in this study by incorporating three wind conditions of progressively increasing velocities and crosswind gust amplitudes. One condition was no wind, while the others were of medium and high amplitude.

Effects of Simulator Motion--Several studies have shown that simulator motion is a contributing factor to performance differences in evaluations of different flight displays. Matheny, Dougherty, and Willis[10] compared two attitude indicator displays (moving airplane and moving horizon) and found that without motion, the moving airplane indicator was superior to the moving horizon; but when motion cues were added, no performance differences were evident. Furthermore, performances were generally improved on both display formats when motion was added.

Further evidence of this effect was found by Ince, Williges, and Roscoe[1] who compared three types of motion: 1) no motion, 2) standard simulator motion, and 3) washout motion (effect of roll acceleration cues is subliminally and gradually eliminated subsequent to a roll input by the pilot). The third condition produced results most representative of a complementary in-flight study.[11] Thus, these three studies indicate the importance of the incorporation of motion cues to enhance the generality of results from display evaluation studies conducted in simulators.

The effect of simulator motion (six degrees of freedom motion vs. no motion) was also investigated in this study. All display conditions were evaluated in the presence and absence of simulator motion.

Objectives--The major objective of this study, therefore, is to explore the relationship between potential workload measures such as physiological and visual response variables and conventional flight performance error measures. Further establishment of a relationship between these measures, as shown in previous studies,[4, 5, 6, 7, 12, 13] would provide support for developing a workload metric useful under virtually any operational/task conditions.

A second important objective is the comparison of conventional and currently considered computer generated displays for VTOL aircraft. Three displays were chosen for this comparison, and results were evaluated in terms of performance error and workload reduction during helicopter landing approaches.

Two additional variables were included to evaluate the effect of simulator motion cues on performance and the effect on performance of crosswind gust amplitude during landing. The primary rationale for the inclusion of increasing wind amplitude was to increase task difficulty as indicated in the conceptual approach. In addition, the specific performance attained under the three wind conditions used was also of interest.

Use of trade names or names of manufacturers in this report does not constitute an official endorsement of such products or manufacturers, either expressed or implied, by the National Aeronautics and Space Administration.

SECTION 3

METHOD

Overview

Six pilots flew a total of 90 approaches each to hover in the VMS. Each trial consisted of a complete approach divided into three segments of data collection: 1) descent, 2) deceleration, and 3) hover. Experimental conditions for a trial were created by combining display, crosswind, and motion conditions. Physiological, visual response, and conventional flight performance measures were recorded for each trial, and pilot opinion scores were obtained for each major experimental condition.

Simulation System

The VMS facility with Huey-Cobra helicopter dynamics was used in this experiment.[14] A block diagram of the simulation/display is shown in Figure 2. A pictorial representation of the experimenter's control station is presented in Figure 3. The CDC-Cyber 175 computer served as the host computer for simulation software. Signals for the flight display were sent from the Cyber 175 to the ADAGE graphic display system or the flight director. The ADAGE display produced images for two of the three experimental displays (GRAPHICS I and II). The CRT image was transferred to a video display via a graphic-to-video converter and video camera. The signal was then sent to the instrument panel CRT display. The third instrument display was a conventional flight director (F-DIR). Signals from the Cyber 175 drove the ADI (Sperry HZ-6B). The ADI display image was transmitted to the instrument panel CRT via a video camera.

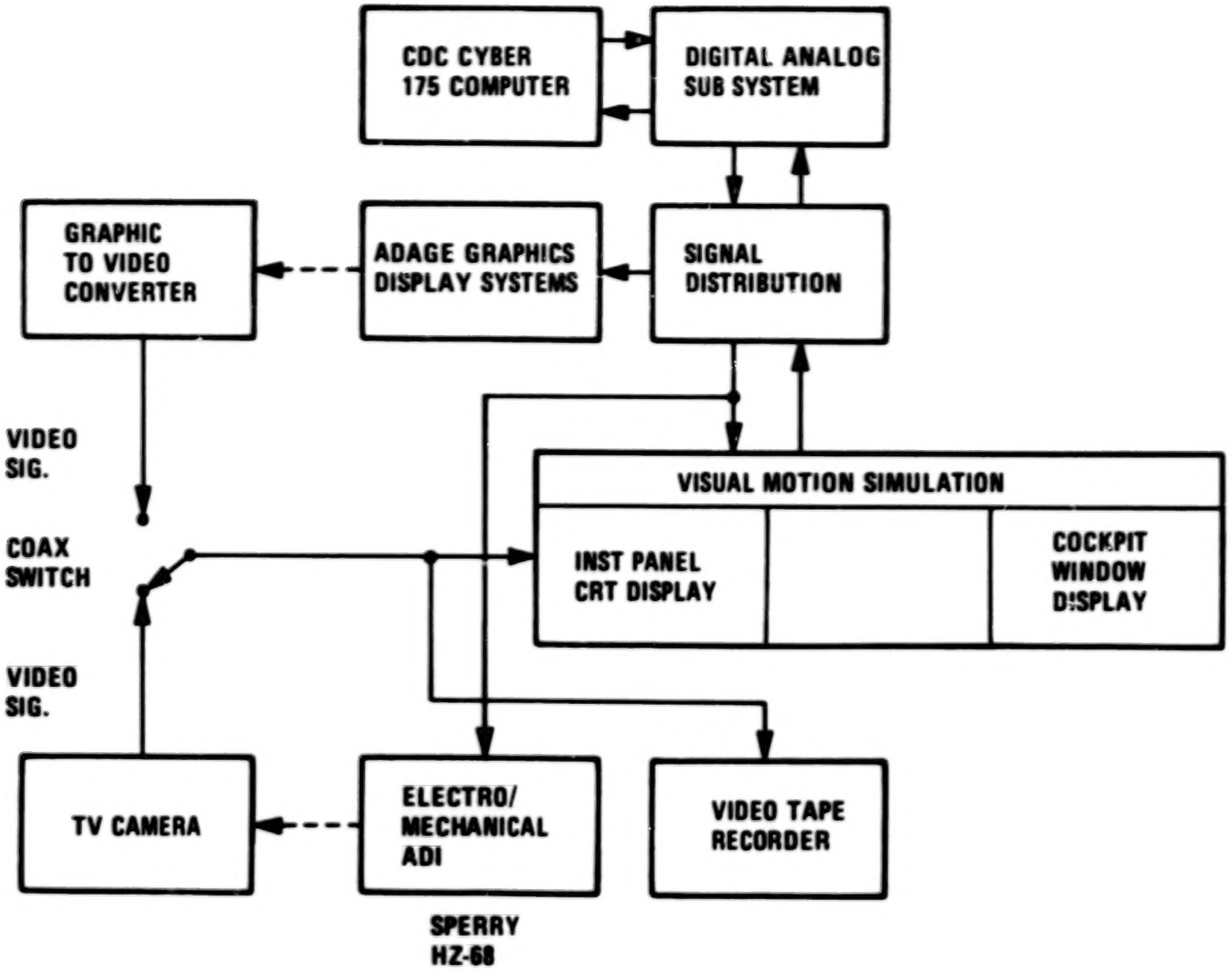

Figure 2. Equipment/Simulator Interfaces for Experiment

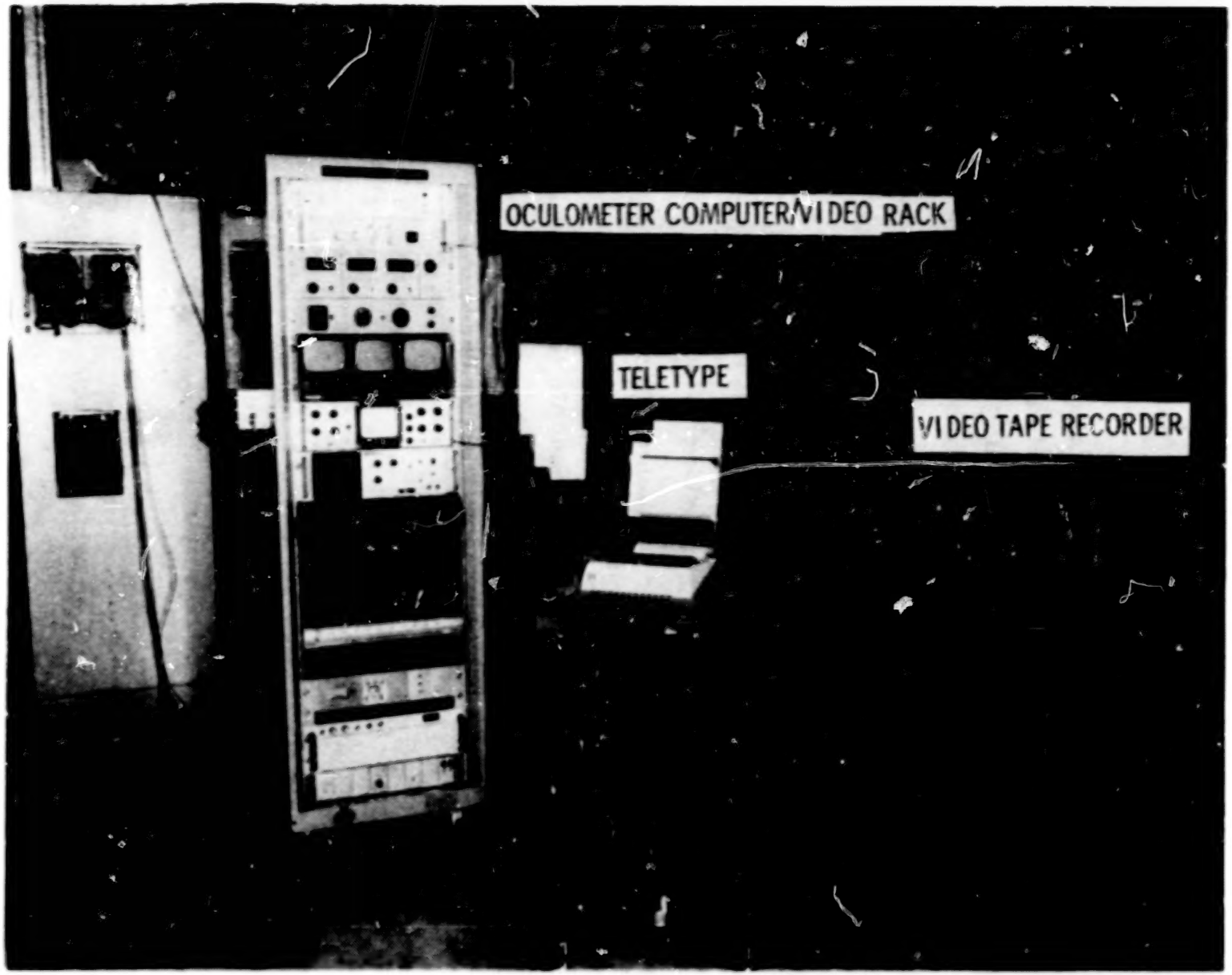

Figure 3. Oculometer Control Station

VMS/Oculometer Installation

The oculometer equipment was located in two general areas. The oculometer optical head and television cameras were mounted in the cockpit, and the analysis and evaluation components were mounted outside the VMS. In the cockpit (see Figure 4), the oculometer's optical head was mounted to the front of the instrument panel below and to the left of the CRT display with the oculometer's moving mirror drive amplifiers located just above the instrument panel. This optical head position placed all five instruments inside the oculometer coverage area. One camera was mounted on the top of the instrument panel directly in front of the pilot looking at the pilot's head. This camera aided the oculometer operator by showing which eye the oculometer was tracking and where the oculometer was searching when the eye was not in track. The other camera located above and behind the pilot's right shoulder provided a real-time scene of the instrument panel. The pilot's lookpoint was superimposed on this scene for real-time viewing by the test director and recorded for later observation. This scene also served as a good check on the oculometer operation during data and calibration runs.

The oculometer computer and associated video equipment (see Figure 3) were located near the VMS. All of the equipment was rack mounted except for the teletype computer interface and the instrument panel video recorder. The oculometer data were sent to the real-time computer for conversion to digital format and storage with the rest of the aircraft data.

Physiological Data Recording--The system used to acquire the physiological data is described below:

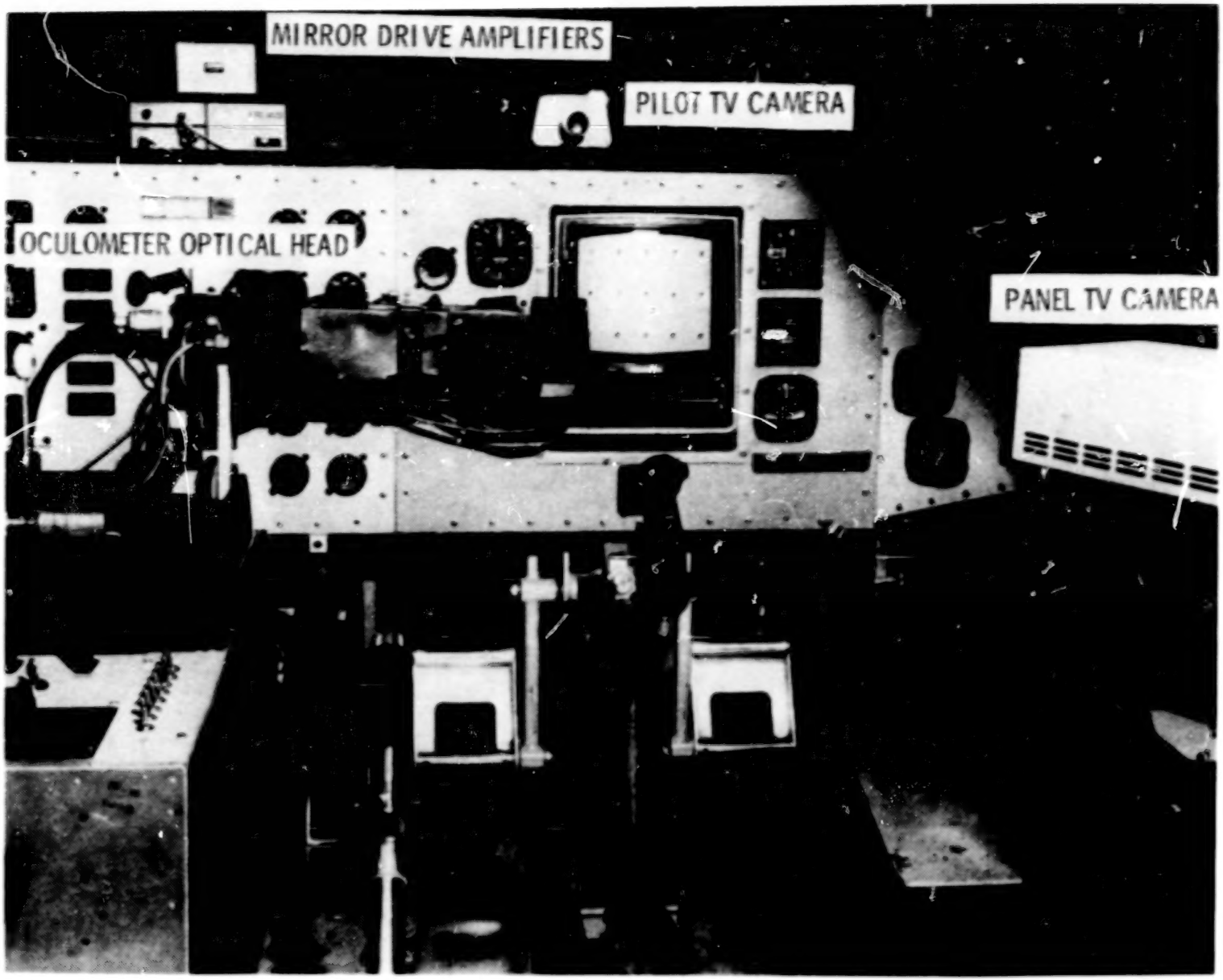

Figure 4. Oculometer Installation in Simulator

Electrocardiogram (ECG): Recorded from electrodes approximately 7.6 cm below the front edge of the armpit with a reference electrode at waist level on the subject's right side. The electrode outputs were conditioned by a Honeywell Accudata 135A biomedical amplifier and ECG isolator. Low and high pass filters were set at 0.05 Hz and 100 Hz. Overall voltage gain was approximately 1000:1.

Electromyogram (EMG): Recorded from electrodes on left and right forearms (two data channels). The electrode outputs were processed by a Honeywell Accudata 135A amplifier with EEG/EMG preamplifier. Low and high pass frequency filters were set at 50 Hz and 2500 Hz. Overall voltage gain was approximately 500:1.

Respiration: Recorded from mercury chestband respiration transducer and amplified with a Honeywell Accudata 137 respiration control/tachometer. The waveform output was used.

The above physiological variables were selected based on previous work [4, 5, 6, 7, 8] as having the best potential for producing extracted features that are correlates of task performance and pilot-opinion scores.

Experimental Design

There were five factors in the experimental design: 1) displays (3 levels), 2) winds (3 levels), 3) motion (2 levels), 4) replications (5 levels), and 5) subjects (6 levels). Thus, it was a 3 x 3 x 2 x 5 x 6 factorial design. Total data points of 540 result from this design. Replications refers to the number of flights each subject flew with identical combinations of displays, winds, and motion. Figure 5 shows the 18 experimental conditions.

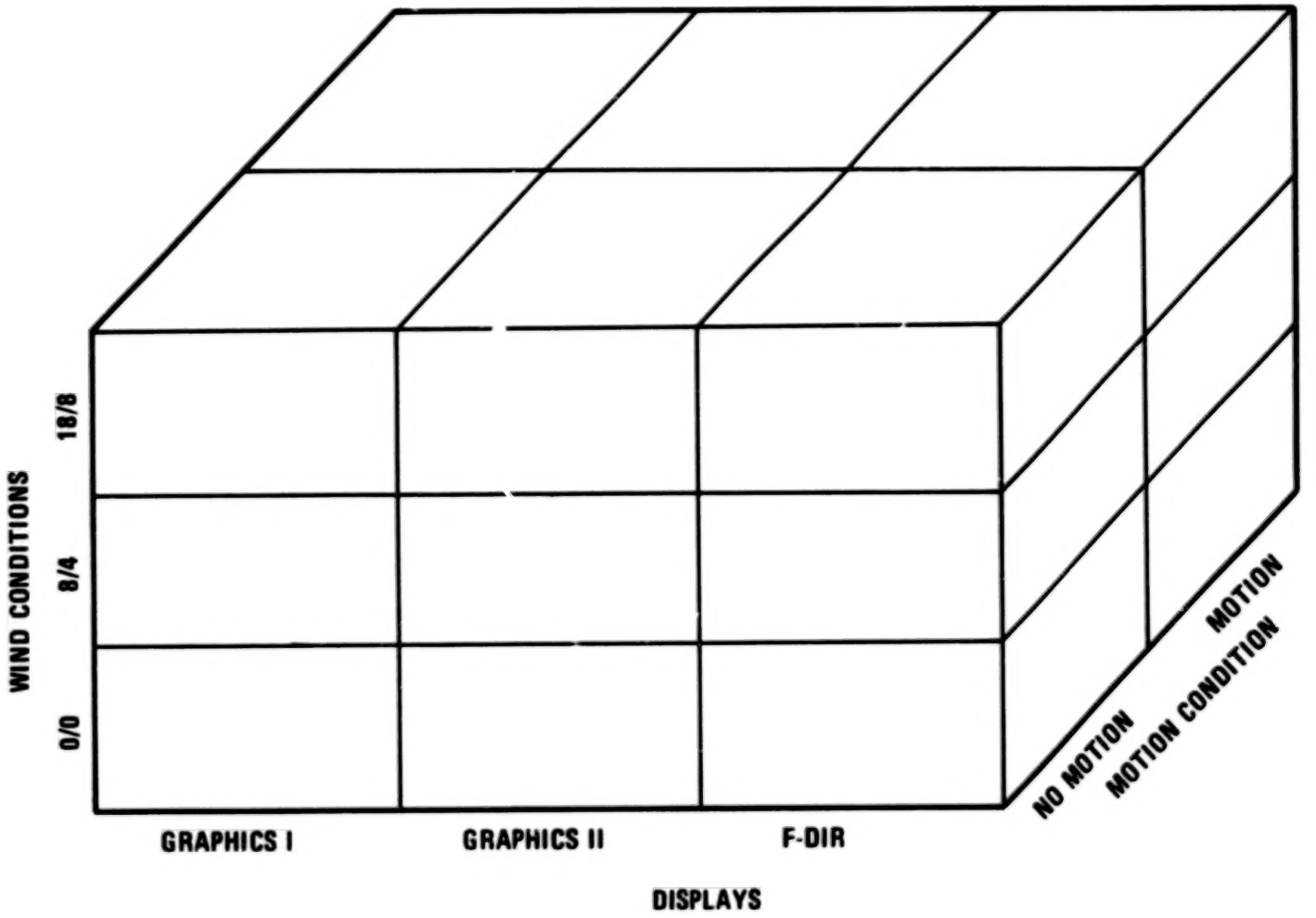

Figure 5. Experimental Design

Simulator Motion--The two motion conditions consisted of: 1) washout motion [14] provided in the Langley moving base VMS, and 2) a no-motion condition using the simulator as a fixed-base device.

Displays--

GRAPHIC I and GRAPHIC II: The two computer produced graphic flight displays are shown in Figures 6a and 6b. The basic difference between these displays is that: 1) pitch command is separated from roll command in the GRAPHIC II display and represented as the vertical position of the two wedges, and 2) roll and pitch indications are combined on the GRAPHIC I display, while power has a separate indication. We hypothesized that the GRAPHIC II display would create a more difficult visual information integration problem for the aviator than the GRAPHIC I display.

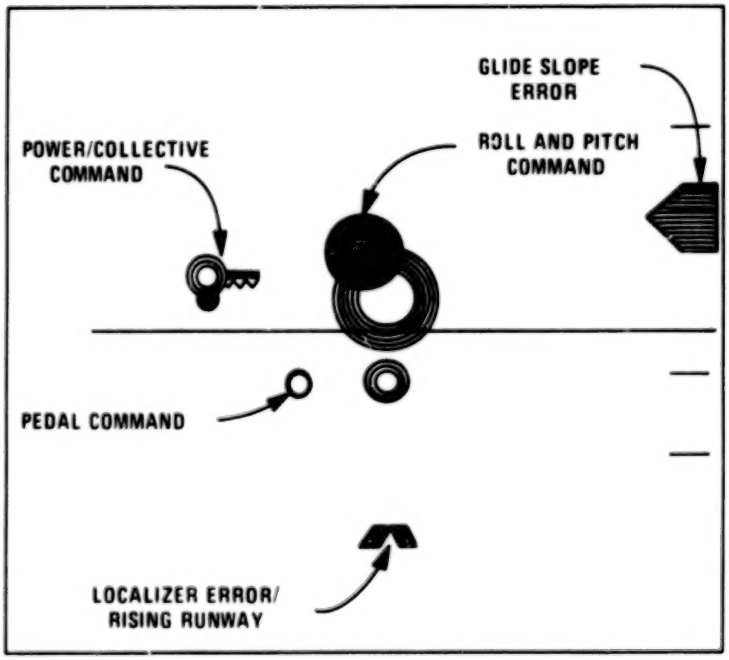

Figure 6a. GRAPHIC I Display

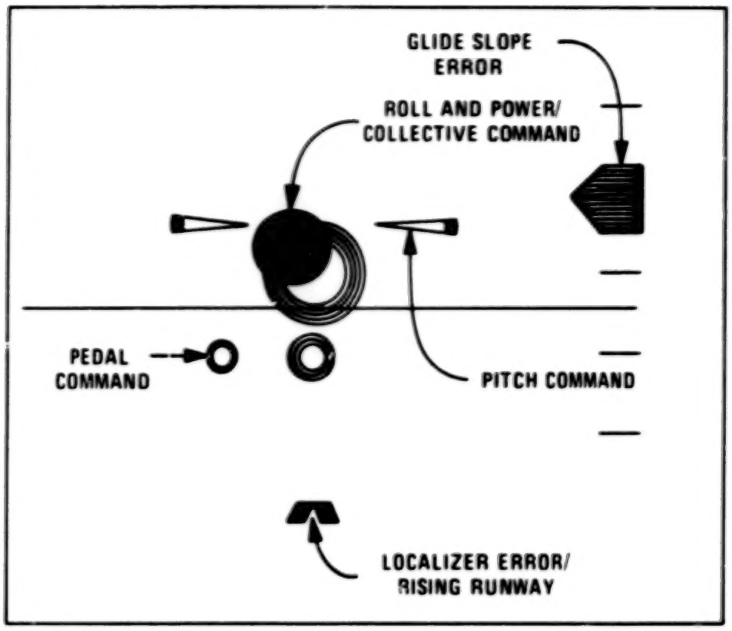

Figure 6b. GRAPHIC II Display

ADI flight director: The conventional electromechanical ADI flight director used in this study is presented in Figure 6c.

Winds--Three conditions of increasing wind and gust amplitude were used to cause conditions of increasing difficulty. Crosswind steady-state velocities (in knots) and RMS gust velocities were: 1) no wind, 2) 8 knots with 1.3 m/sec (4 ft/sec) gusts, and 3) 16 knots with 2.6 m/sec (8 ft/sec) gusts. These three conditions will be referred to by the following coding scheme:

- Condition 1 as 0/0
- Condition 2 as 8/4
- Condition 3 as 16/8

The gust model used to generate these conditions during the trials was based on a model discussed by Pritchard.[15] Wind direction was an absolute side force from the left.

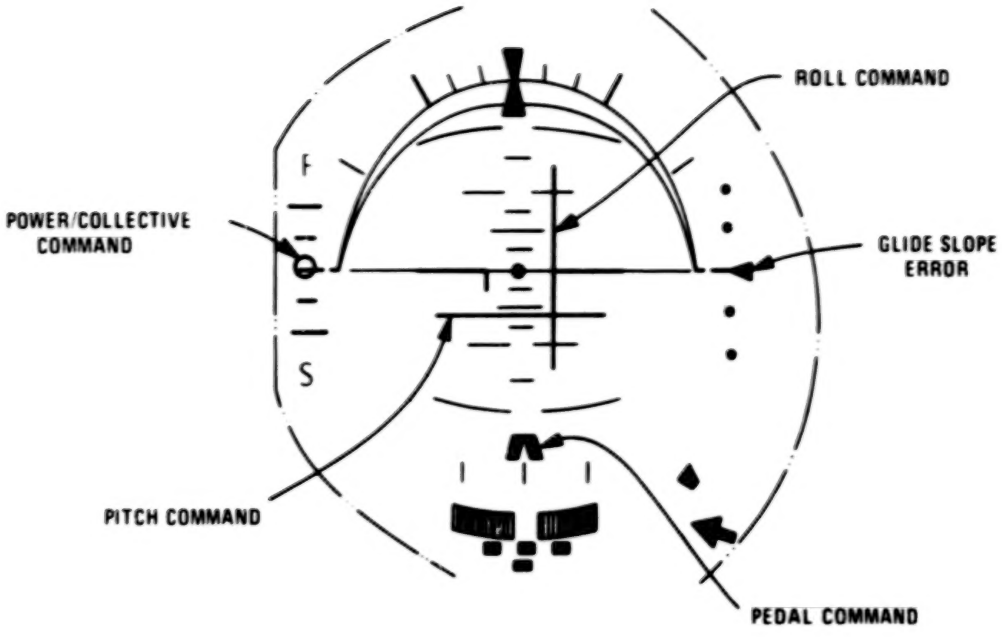

Figure 6c. Flight Director Display

Subjects

Two test subjects were Army civilian research pilots; two were military test pilots. All of them were current. The two remaining test subjects were flight test engineers with prior military helicopter pilot experience.

Experimental Procedure

Flight Task Segments--The pilot's task was to complete an approach to landing sequence on each trial under the specific combinations of wind, motion, and display conditions outlined above. Each trial, or approach, consisted of three segments (see Figure 7): 1) descent, 2) deceleration, and 3) hover. Prior to the descent segment, a turning maneuver was required to intercept the final approach heading. Data collection was begun as soon as the glide path was

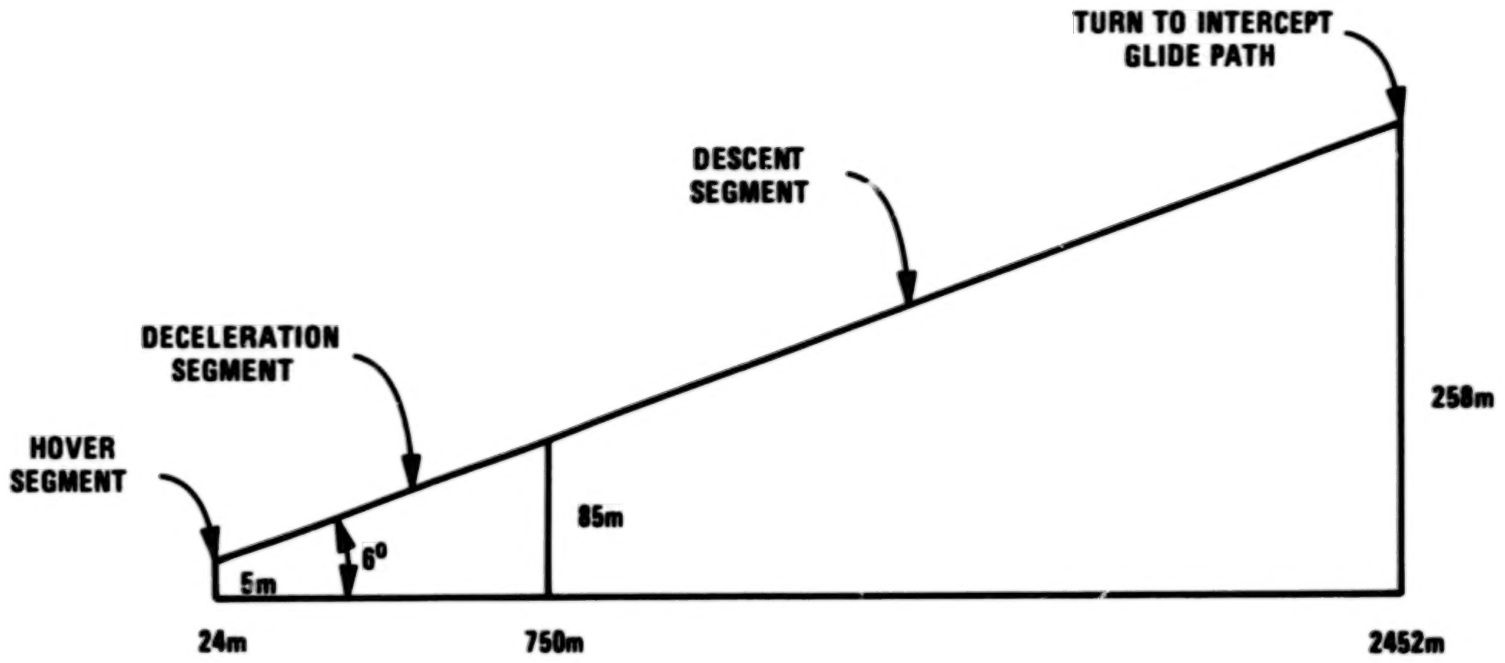

Figure 7. Landing Approach Range and Altitudes

intercepted. The deceleration segment was defined as the 815m to 24m range from touchdown point. The deceleration profile used in this study had a maximum deceleration value of 0.12g with a ground speed value of 65.2 knots at a range of 903m. The hover segment was begun when the pilot reached the 24m range at 6m altitude. This segment was terminated after the hover conditions were maintained for 45 seconds. Data was analyzed separately for each of the three segments because they represented different requirements on the pilot and the displays.

Experimental Sessions--Each experimental session consisted of nine approach conditions. The first three approaches were performed with the 0/0 wind condition, approaches four through six with the 8/4 wind condition, and approaches seven through nine with the 16/8 wind condition. The display conditions were counterbalanced within wind conditions. Two subjects shared the simulator on an alternating basis. Each session lasted approximately 45 minutes. Motion vs. no-motion conditions were alternated for each subject.

Data Analysis Procedures

The statistical analysis procedures followed techniques applied in References 5, 6, and 7. These procedures are shown in Figure 8. Analog data tapes are sampled and selected features extracted. Physiological features are simple statistical summaries (that is, mean and standard deviations) of selected waveform characteristics computed over some interval.

Feature data obtained from analog tape-recorded signals and other response data are then normalized by

$$Z_{ij} = \frac{X_{ij} - \overline{X}_j}{\sigma_{x_j}}$$

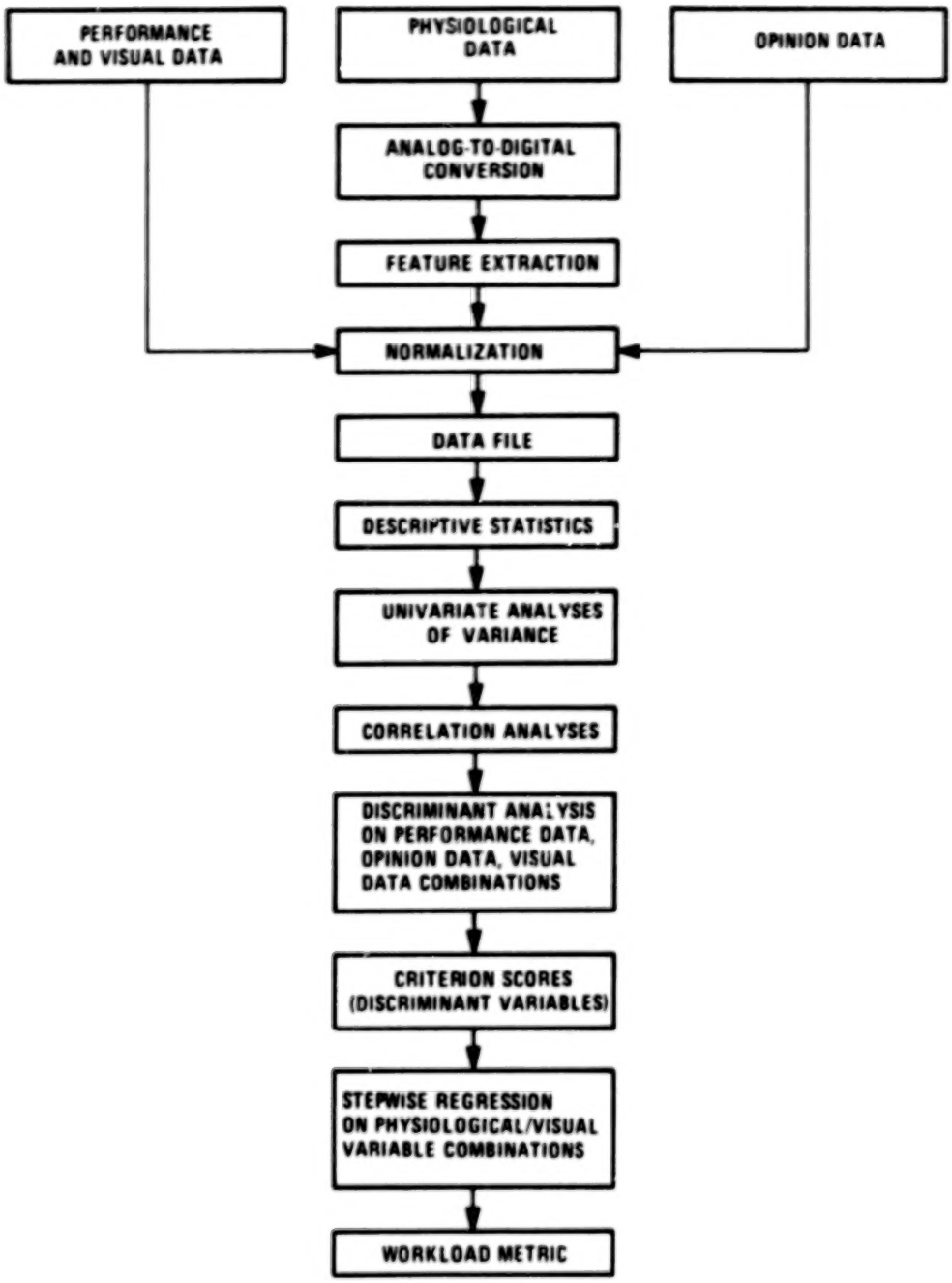

Figure 8. Data Analysis Strategy

where

X_{ij} = raw score value i on response measure j

Z_{ij} = normalized value of X_{ij}

$\overline{X}_j$ = mean raw score value on measure j

σ_{x_j} = standard deviation of raw scores for measure j

Normalization in the above manner generates a transformed set of data which places all response measures on a common scale with zero mean and unity standard deviation for each measure. The resulting file containing all normalized data provides the data base for all subsequent analyses. Simple statistics (mean and standard deviations), univariate analyses of variance, and correlation coefficients are computed on all variables in the data base to summarize effects of test conditions and interrelationships between variables.

Multiple discriminant and multiple regression techniques are the primary statistical tools applied in the analysis procedure. These techniques are summarized below and described in greater detail in References 4, 5, and 16.

The approach to derivation of the actual workload metric is a prediction problem. Various combinations of data sets are used to generate criterion scores which are derived from discriminant analysis. The predictor scores are derived from the physiological and/or visual data. Several combinations of these data sets were then used in the present study. These combinations are outlined as follows.

Problem Set	Regression Analysis Groups	Discriminant Analysis Groups
A	Physiological data	Performance/opinion data
B	Physiological data	Performance/opinion and visual performance data
C	Physiological data	Visual data
D	Physiological and visual response data	Performance/opinion data
E	Visual response data	Performance/opinion data

It should be noted that visual (oculometer) data was used both as a predictor and as a criterion variable in separate analyses. This was because of the nature of the variables involved. Visual data could be considered in a physiological sense and thus grouped with the physiological features or the performance variables in developing discriminant functions.

Discriminant Analysis--The first step in this process is to derive linear combinations of performance and opinions scores that best differentiate between the 18 conditions. This is accomplished by multiple discriminant analysis. A discriminant function resulting from this analysis defines a single scale composed of the original set of performance and opinion data and can be expressed by the general form

$$D_i = \sum_{j=1}^{n} (a_j Z_{ij}) \qquad (1)$$

where

D_i = score i on discriminant scale D

Z_{ij} = normalized score Z_i on performance and/or visual data variable

a_j = weighting coefficient on variable j

n = number of variables included in the discriminant analysis

In effect, values of D for Equation (1) create a "new" variable which is a composite based on the performance and opinion variables entered into the analysis. Advantages of this technique are that the information content in each variable is used toward maximization of group (condition) differences, and the relative contribution of each variable can be assessed. Composite variables generated in this manner were statistically analyzed in the same way as the individual variables constituting the discriminant function (see Figure 8).

Stepwise Regression Analysis--A discriminant function produced by the process described above can be interpreted as a scale of difficulty imposed by the various experimental conditions. A discriminant score derived from performance and opinion data on a particular trial represents a position on this scale relative to scores from all other trials. Using the discriminant score as a criterion measure, stepwise multiple regression may be used to derive the predictive relationship between the physiological/visual response measures and this criterion score.

Stepwise regression is a procedure for selective examination of the available predictor variables for their individual contributions to the explanation of variance in the criterion measure. The variables that are included in the final equation are the set with the highest unique contribution to prediction of criterion variability. At each step, a partial F test for each variable is computed and

compared to a preselected value. A variable not yet in the equation which provides the greatest contribution to accounting for the variance is added to the equation. As variables are added, a variable placed in the equation on previous steps may no longer provide significant unique contribution to prediction of criterion variability. If so, that variable is removed. This stepwise process is continued until none of the predictor variables can be incorporated into, or removed from, the regression equation based on the partial F test.

The result is a linear combination of a minimum set of predictor variables and associated weighting coefficients which best predict response on the criterion variable. Expressed as a prediction equation, this result is

$$\hat{D}_i = \sum_{j=1}^{m} (b_j Z_{ij}) \qquad (2)$$

where

$\hat{D}_i$ = predicted score i on discriminant scale D

Z_{ij} = normalized score Z_i on physiological or visual response variable j

b_j = weighting coefficient on variable j

m = number of variables providing significant unique contribution to prediction of scores on discriminant scale D

Within the conceptual framework of this study, Equation (2) above operationally defines the form of a workload metric. Thus,

$$W_i = \sum_{j=1}^{m} (b_j Z_{ij}) \qquad (3)$$

where

W = workload metric

Stepwise regression analyses were performed on several combinations of predictor variables to identify a combination which best characterized workload with as few variables from as few sources as possible. Variable combinations analyzed are discussed in Section 4.

Univariate Analysis of Variance Tests--A five factor analysis of variance was performed on each variable to determine the effects of displays, motion base, and wind. A fourth factor, replications, was analyzed but will not be reported in this study. Each of the above effects was tested by the appropriate subject-effect interaction component.

Variables Analyzed

Physiological Features--Twenty-one physiological features were extracted on each trial. These features are listed in Table 1 with their descriptions and a mnemonic indicator which will be used to abbreviate references to each variable in subsequent sections.

Physiological features represented in variables 1 through 20 are defined in Figure 9. ECG waveform amplitudes are defined relative to a common baseline which is the mean signal level recorded on each trial (see Figure 9 for examples of R- and S-wave amplitudes). Samples of EMG and respiration amplitude are defined by absolute value of the difference between consecutive peaks (slope reversals). The ECG R-wave interval is the duration between R-wave peaks in this periodic waveform. Respiration duration is defined in a similar manner as the interval between successive signal peaks in the same direction.

Table 1. Physiological Performance Features

Variable	Description	MNEMONIC
1	EMG, amplitude, right, mean	EMGARM
2	EMG, amplitude, right, standard deviation	EMGARS
3	EMG, amplitude, left, mean	EMGALM
4	EMG, amplitude, left, standard deviation	EMGALS
5	Respiration amplitude, mean	RESAMP
6	Respiration amplitude, standard deviation	RESAMS
7	Respiration duration, mean	RESPDM
8	Respiration duration, standard deviation	RESPDS
9	ECG, amplitude R-wave, mean	ECGRAM
10	ECG, amplitude R-wave, standard deviation	ECGRAS
11	ECG, R-wave duration, mean	ECGRDM
12	ECG, R-wave duration, standard deviation	ECGRDS
13	ECG, P/R ratio	ECGP/R
14	ECG, Q/R ratio	ECGQ/R
15	ECG, S/R ratio	ECGS/R
16	ECG, T/R ratio	ECGT/R
17	ECG, P interval	ECGPIN
18	ECG, Q interval	ECGQIN
19	ECG, R interval	ECGRIN
20	ECG, S interval	ECGSIN
21	ECG, T interval	ECGTIN

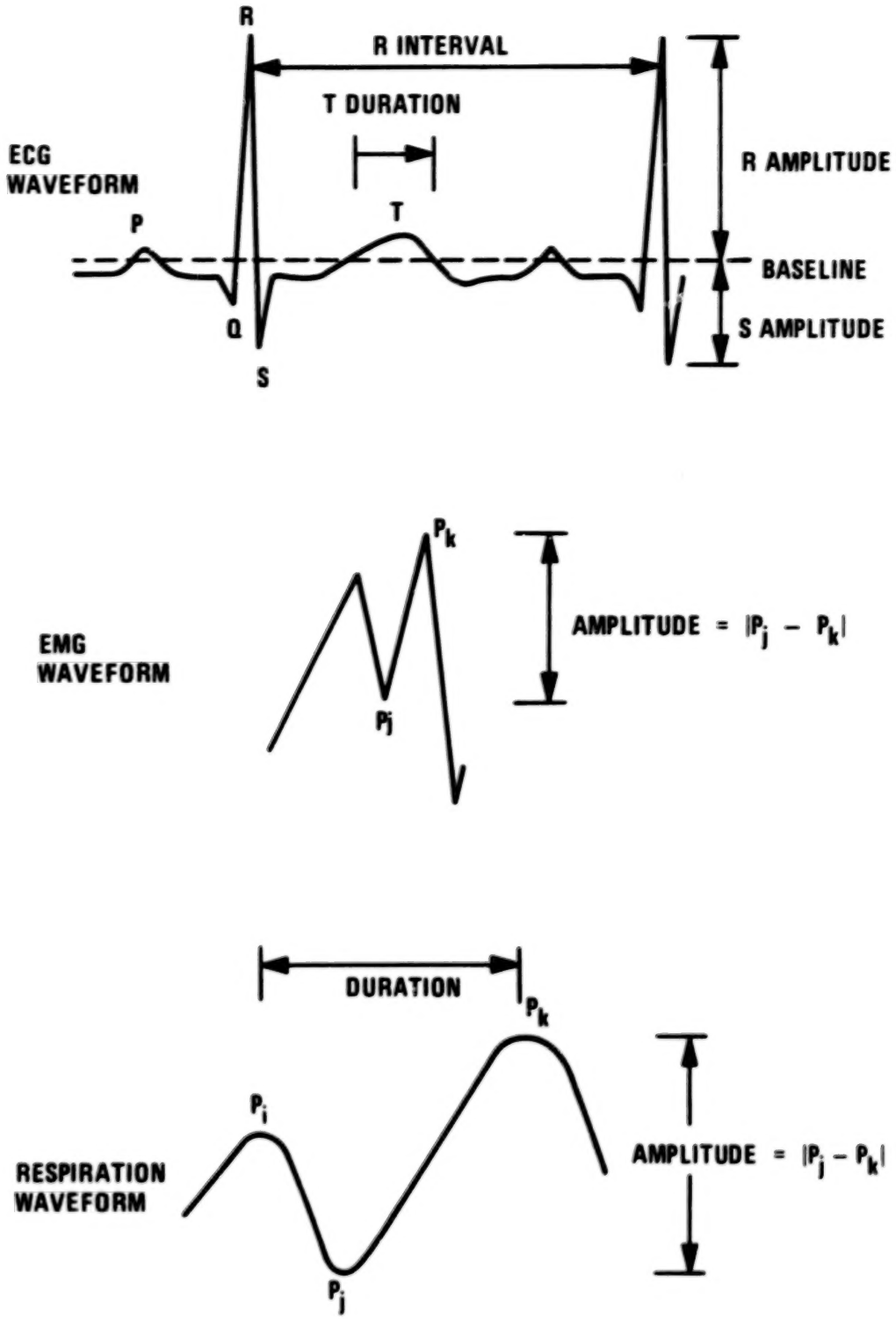

Figure 9. ECG, EMG, and Respiration Waveform Features

Flight Performance Variables Recorded--Fourteen flight performance variables were recorded for each approach segment. A list of these variables is presented in Table 2.

Visual Response Measures--Seven visual response measures were recorded during simulation trials. These measures are identified in Table 3.

A dwell time consisted of the number of continuous lookpoints that were within a 1.27 cm radius of the centroid of the previous lookpoints of the current dwell. A minimum of four points were needed to define a dwell. Three were

Table 2. Flight Performance Variables

Variable	Description	Mnemonic
1	Percent display pitch error	PITCH
2	Percent display roll error	ROLL
3	Percent display power error	POWER
4	Percent display heading error	HEADING
5	Roll acceleration	ROLLAC
6	Pitch acceleration	PITCHAC
7	Yaw acceleration	YAWACC
8	Speed error	SPEEDER
9	Control position, pitch axis	S/PITCH
10	Control position, roll axis	S/ROLL
11	Control position, yaw axis	S/YAW
12	Power setting	POWSET
13	Altitude error, feet	ALTERR
14	Cross range error, feet	CXERR

Table 3. Visual Response Measures

Variable	Description	Mnemonic
1	Saccade length mean	SACCLM
2	Saccade length standard deviation	SACCLS
3	Dwell time mean, (sec)	DWELLM
4	Dwell time standard deviation, (sec)	DWELLS
5	Fixation rate (fixations/sec)	FIXRATE
6	Blink rate (blinks/sec)	BLINKR
7	Pupil diameter (mm)	PUPILD

accepted if the first and last were less than 1.27 cm apart. A dwell was not stopped by a "no track logic signal" such as would occur during a blink. A blink consisted of a no track logic signal lasting from .125 to .375 second. Any no track logic signals lasting for longer than a blink were subtracted from the total run time for that segment so that the rate calculations would not be too misleading.

Opinion Questionnaire--An opinion questionnaire (see Figure 10) was administered to each pilot for each of the display/motion conditions to obtain a scalar rating of overall task workload. This form is based on the Cooper-Harper rating scale for handling qualities[17] which was modified for purposes of the present study to focus on task workload rather than aircraft handling qualities. It must be emphasized that the form as modified in Figure 10 has not been validated as a workload rating scale. Inferences of this modified form's validity should not be made based on extensive previous work and experience with the Cooper-Harper scale.

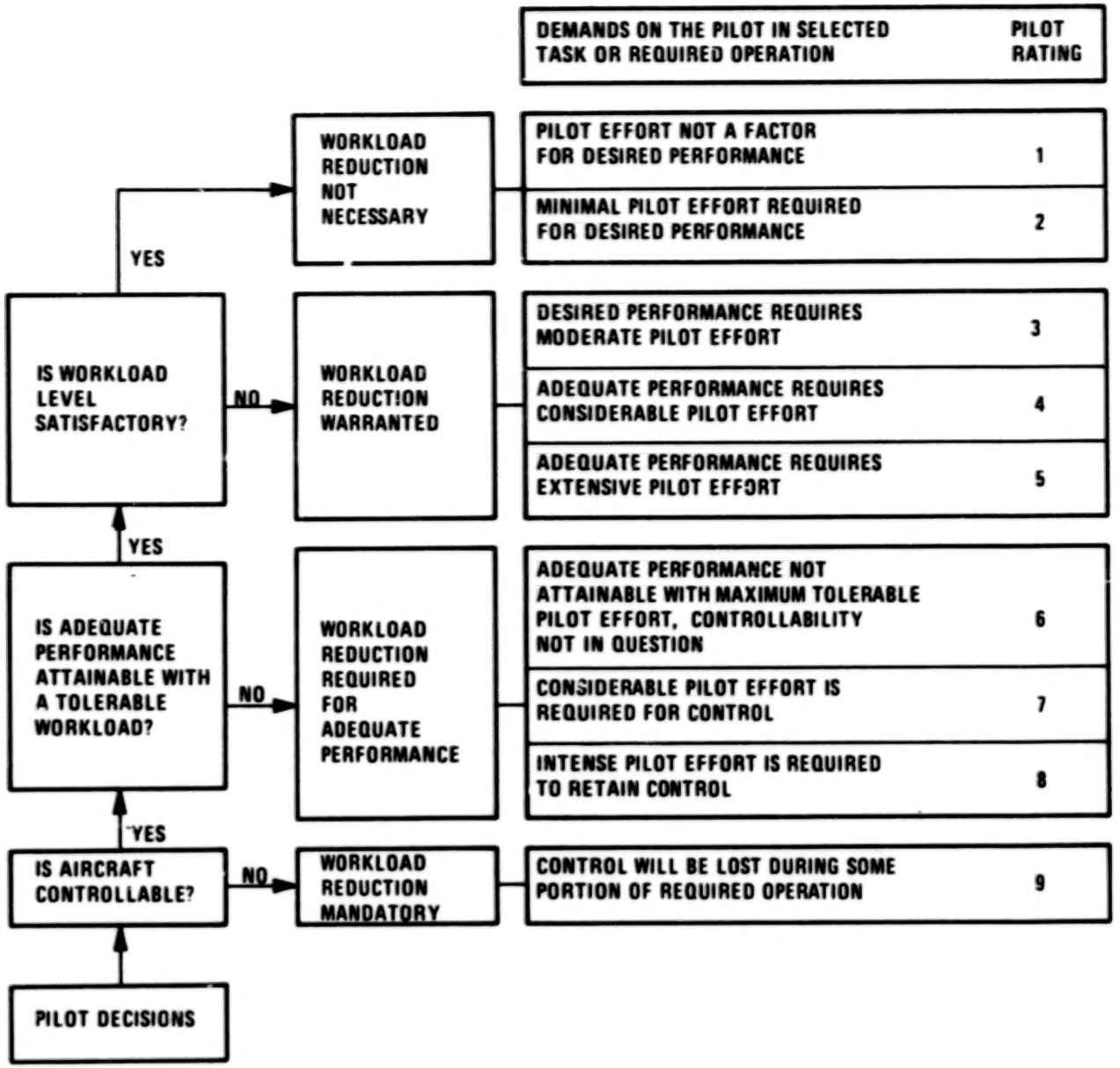

Figure 10. Workload Rating Scale

SECTION 4

RESULTS AND DISCUSSION

Reporting of results will be divided into univariate analyses of variance, correlation, multiple discriminant functions, and multiple regression.

Univariate Analyses of Variance

Tables 4 through 6 summarize the main and interaction effects for the three data classes across flight segments. The mnemonics used in these tables correspond to the variable names shown in Tables 1 through 3 for physiological, flight performance, and visual response data classes, respectively. Cell means are found in Appendix A. Grand means across effects are presented in Appendix C.

Physiological Data--

Displays: Right EMG amplitude and standard deviation were significantly higher for the GRAPHIC II display in the approach segment only. The flight director and GRAPHIC I displays produced nearly equal activity for these variables. Left EMG measures indicated high activity for GRAPHIC II, medium activity for GRAPHIC I, and least activity for the flight director. Although these effects were consistent across flight segments, this trend was not statistically significant in any segment.

Winds, motion, and their interaction: Figures 11 and 12 show the combined effects of winds and motion on four statistically significant physiological variables: EMGRAM, EMGARS, RESAMS, and ECGRIN.

Table 4. Summary of Univariate Analyses of Variance on Physiological Performance Measures[a]

	Experimental Effect						
Variable	Displays (D)	Winds (W)	Motion (M)	(Interactions) DW	DM	WM	DWM
EMGARM	1	23	123			123	
EMGARS	1	23	23			123	
EMGALM		1					
EMGALS		3					
RESAMP							
RESAMS		123	1			1	
RESPDM			1				
RESPDS						1	
ECGRAM					3	3	
ECGRAS							3
ECGRDM							
ECGRDS							
ECGP/R		1					
ECGQ/R							
ECGS/R		3					
ECGP/R							
ECGPIN		3	3				
ECGQIN							
ECGRIN			123		2	3	
ECGSIN	3		2				
ECGTIN	1		3				

[a]Flight segments represented by number (1 = approach, 2 = deceleration, 3 = hover); significance level is $p \leq .05$, unless segment is underscored, indicating $p \leq .01$.

For both EMGRAM and EMGARS, the main effect of motion shows increased muscle tension amplitude and deviation for motion base conditions over fixed base conditions. The effect of winds is primarily due to the increase found in the 16/8 wind condition with the moving base. The fixed base conditions showed no such changes across wind amplitude increase.

For RESAMS, a measure of respiration amplitude deviation across a trial, the main effect of winds was significant. Increasing gust amplitude produced an increase in deviation. No effect was evident for motion.

For ECGRIN, a measure of time between ECG peaks in the waveform, motion was significant. Shorter peak-to-peak times were observed in the moving base condition.

Note the general consistency of the above findings across all three flight segments, as evident in Figures 11 and 12. No significant effects were observed for respiration measures, although amplitude was generally higher with the F-DIR display.

Consistency with previous results: Muscle activity level (EMG) has been shown to be related to workload in tracking type tasks.[18] This result has also been reflected in similar experiments in the workload metric series.[3, 4, 5, 6, 7] This relationship was substantiated in the present study with right arm EMG amplitude and deviations increasing with increased difficulty (wind conditions). The moving base condition and GRAPHIC II display condition also produced high EMG activity suggesting a higher overall workload in these conditions. This interpretation should be viewed with extreme caution, however, as this result could easily be caused by the general instability of the body in the moving base

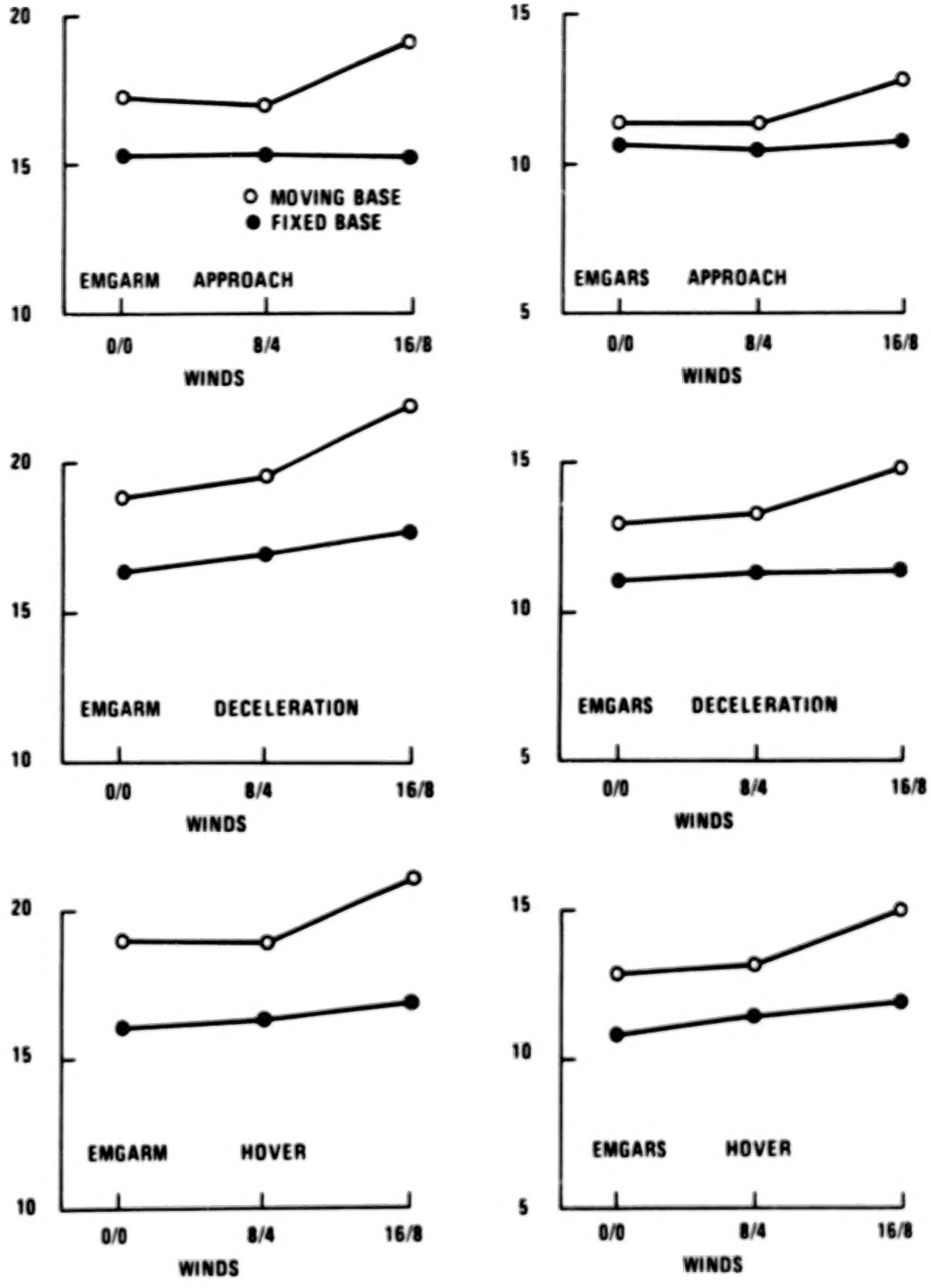

Figure 11. EMGARM and EMGARS (Arbitrary Units) Changes Over Wind and Motion Conditions for Approach, Deceleration, and Hover

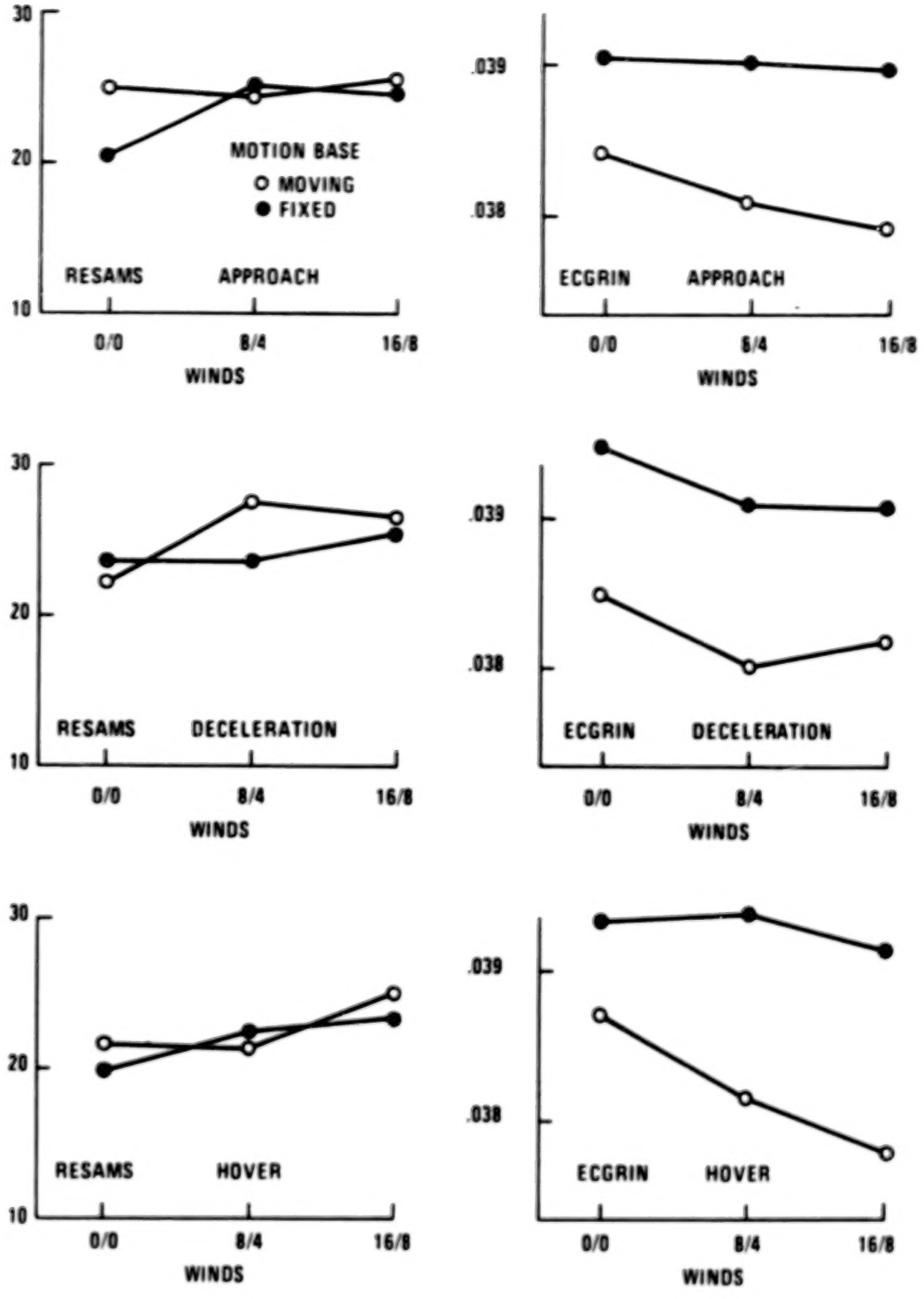

Figure 12. RESAMS (in cm) and ECGRIN (Arbitrary Units) Changes Over Wind and Motion Conditions for Approach, Deceleration, and Hover

condition. With the motion system on, certain arm movements may be greater because the pilot is working harder to keep the system stable.

Respiration amplitude/deviation has been found to be positively related to workload level in previous studies.[4, 5, 6, 7, 8, 18] This finding was consistent with the amplitude deviation variable (RESAMS) across winds. Deviations in breathing increased with increasing wind velocity conditions.

Heart rate (time interval), reflected in r-r mean interval (ECGRIN), was sensitive to wind increases directly supporting previous work by Stackhouse.[6]

In general, physiological measures differentiate motion vs. no motion and the high crosswind condition from the other two wind conditions, particularly in the motion condition case.

Flight Performance Variables--Fourteen flight performance variables were recorded on each landing approach trial. These included conventional error measures, stick positions, and acceleration amplitudes. A complete listing of these 14 variables was shown in Table 2.

Table 5 shows results of univariate analyses of variance tests on all 14 measures. Note that significance is indicated by the presence of a flight segment number; absence indicates non-significance. For example, heading error was significant for flight segments 2 and 3 for the main effect of displays.

Displays: Significant effects across flight segments produced the orders of merit indicated below for these displays. Listing of displays is from lowest to highest error or low to high accelerations. Listing of variables is in descending order of significane of these variables.

Table 5. Summary of Univariate Analyses of Variance on Flight Performance Measures[a]

Variable	Experimental Effect						
	Displays (D)	Winds (W)	Motion (M)	(Interactions) DW	DM	WM	DWM
Pitch error	123	123					
Roll error		123				23	
Power error							
Heading error	23	123	1	1			
Roll acceleration	123	123	23			3	
Pitch acceleration	123	123	123		123	2	
Yaw acceleration		123	23				2
Speed error	3	123	1			3	1
Pitch position		23					
Roll position		123	1				
Yaw position	3	13	12				1
Power setting		1	13				2
Altitude error		123	2			3	2
Crosstrack error		23	3				

[a]Flight segments represented by number (1 = approach, 2 = deceleration, 3 = hover); significance level is $p \leq .05$, unless segment is underscored, indicating $p \leq .01$.

Variable	Order of Merit
Roll acceleration	GRAPHIC I, GRAPHIC II, F-DIR
Pitch acceleration	GRAPHIC I, GRAPHIC II, F-DIR
Heading error	GRAPHIC I, GRAPHIC II, F-DIR
Pitch error	F-DIR, GRAPHIC I, GRAPHIC II
Airspeed error	F-DIR, GRAPHIC I, GRAPHIC II

For pitch acceleration, GRAPHIC II and F-DIR were virtually equal.

The GRAPHIC I display outperformed the F-DIR on four performance scores. The difference might have been more pronounced if the test subjects had had equal prior experience on all displays. Most of the subjects were experienced on the conventional flight director, and had little experience on the computer generated displays.

Winds: Winds produced highly significant and consistent effects across segments and variables. Increasing wind produced increasing error or accelerations in all cases.

Motion: The effect of motion occurred about equally across segments. Airspeed error was lower with the fixed base system. Heading error showed the opposite effect.

Roll and pitch accelerations decreased in the fixed base condition in deceleration and hover segments. Yaw accelerations decreased with the moving base in these segments.

Interactions: Interactions were generally inconsistent across segments and variables. Pitch acceleration consistently showed an interaction in the display X motion conditions. The accelerations were much greater with the F-DIR/moving base condition vs. the F-DIR/fixed base condition. The other displays did not show as great a difference between fixed and moving base conditions. In the no-motion case, the GRAPHIC II and F-DIR were similar.

Visual Response Measures--Seven visual response measures were recorded on each trial. A complete listing of these measures is shown in Table 3. Table 6 summarizes the univariate analyses of variance on these measures.

Table 6. Summary of Univariate Analyses of Variance on Visual Response Measures[a]

	Experimental Effect						
Variable	Displays (D)	Winds (W)	Motion (M)	(Interactions) DW	DM	WM	DWM
SACCLM	123						
SACCLS							
DWELLM	123		123		123		
DWELLS	123		123		123		
FIXRATE	123	123	123		123	13	
BLINKR	3	1	123				
PUPILD	12		123		123		

[a]Flight segments represented by number (1 = approach, 2 = deceleration, 3 = hover); significance level is $p \leq .05$, unless segment is underscored, indicating $p \leq .01$.

Displays: Several consistent results were observed for these measures:

- DWELLM was highest in GRAPHIC II condition.
- FIXRATE was lowest in GRAPHIC II condition.
- BLINKR was highest in GRAPHIC II condition.
- PUPILD was highest in GRAPHIC II condition, and lowest in the F-DIR condition. GRAPHIC I was intermediate in value on this variable.

Winds: Winds only produced a significant change in FIXRATE which increased with increasing gust amplitudes in all flight segments.

Motion: The following results were highly consistent across flight segments:

- DWELLM, DWELLS, and PUPILD were significantly larger in the fixed base condition.
- BLINKR, FIXRATE were significantly larger in the moving base condition.

Interactions: A consistently strong interaction appeared between motion and displays in all three segments for DWELLM, DWELLS, FIXRATE, and PUPILD measures. This interaction was traced to the fact that with the fixed base condition, DWELLM, DWELLS, and PUPILD means are all much larger with the GRAPHIC II display condition than the other two display conditions. Fixation rate was much smaller for the GRAPHIC II fixed base condition than the other two display conditions.

Discussion of visual measures: The literature on eye movement data and workload is highly discrepant and difficult to interpret.[19] In the present study, however, the long dwell times for the fixed base/GRAPHIC II display conditions would implicate this combination as involving higher visual workload. The GRAPHIC II display exhibited tendencies for poor flight performance as well, implicating it as a high workload condition. A plausible explanation is that this display requires longer focuses of attention to integrate information necessary for the flight task.

Fixation rate, inversely proportional to dwell mean time, showed the same trend in the fixed base/GRAPHIC II conditions. Krebs and Wingert[16] have shown that fixation rate increases over increasing difficulty conditions as defined by wind velocity. This is somewhat contradictory with the fact that fixation rate was substantially lower in the GRAPHIC II display condition found to be highly demanding by other measures. It is important to note that there may be certain interactive effects between methods of manipulating workload. Wind as a difficulty manipulator may have contradictory effects on visual movements to that of difficulty changes produced by different displays. Display differences may be caused by required focusing of visual attention to interpret changes tending to decrease fixation rate.

The long saccade length distances in the F-DIR and GRAPHIC I displays compared to short travel in the GRAPHIC II condition also indicates a general focusing of visual attention for the GRAPHIC II display not required with the other displays.

Pupil diameter has been shown to increase with increasing attention or workload demand.[20] PUPILD increased in the present study under the GRAPHIC II

display, fixed base conditions, again implicating this set of conditions as a high workload demand case.

Thus, eye movement measures seem difficult to interpret for a given set of flight conditions such as were tested in the present study. The particular information requirements of the displays have an important impact on the way in which the pilot receives and uses visual information.

Correlation

As previously discussed, physiological, performance, and visual response measures were combined to form a group of 42 dependent scores for each trial. These 42 scores were submitted to a correlation analysis with total N of 540 per measure (all data points in the study).

The correlation matrices for the 42 dependent measures are presented in Appendix B for the three flight segments. The following discussion summarizes the correlation between the major data groups.

Physiological vs. Performance Measures--The following consistent trends apply across flight segments:

- EMG measures, particularly right arm measures, show relatively high positive correlation (+.2 to +.5) with the major flight performance error scores (PITCH, ROLL, POWER, HEADING, SPEEDER, ALTERR).
- Respiration duration and amplitude tend to be negatively correlated with error performance although the result lacks total consistency across segments.

- ECG measures (heart rate, mean amplitude, mean duration) show slight negative correlation with error performance. This result was consistent across segments. Intuitively, this result indicates that lower heartbeat rates and amplitudes tend to be associated with lower performance error.

Visual Response vs. Performance Measures--No consistent relationships were produced between visual response measures and error performance scores.

Physiological vs. Visual Response--

- Several strong relationships were observed between PUPILD and ECG measures.
- SACCLM and SACCLS showed moderate positive relationships with EMGARM and EMGARS measures.
- The balance of visual response measures were not correlated highly with physiological parameters.

Multiple Discriminant Functions

The multiple discriminant weights shown in Table 7 indicate:

- D_p, formed from performance scores only, produced generally consistent weightings across segments for the performance variables. The first segment, approach, is highly dominated by YAWACC. The second segment, deceleration, is dominated by heading error, roll accelerations and roll stick position information. The hover segment is chiefly dominated by stick information in yaw and roll. YAWACC and crosstrack error also contributed to the discriminant function.

Table 7. Discriminant Function Coefficients

	Segment								
	Approach			Deceleration			Hover		
Variable	D_p	D_v	D_{pv}	D_p	D_v	D_{pv}	D_p	D_v	D_{pv}
OPINION	+.08		+.14	-.06		+.09	+.05		-.08
PITCH	-.03		-.04	+.01		-.04	-.11		-.10
ROLL	-.01		-.02	+.06		+.06	+.08		+.08
POWER	+.17		+.18	+.16		+.14	+.09		+.07
HEADING	-.01		-.01	+.44		+.44	+.02		+.03
ROLLAC	+.27		+.22	+.25		+.38	+.02		+.03
PITCHAC	-.22		-.19	-.10		-.11	+.08		+.08
YAWACC	+.84		+.82	-.02		-.05	+.19		+.20
SPEEDER	-.06		-.06	-.07		-.08	+.03		+.03
S/PITCH	-.20		-.20	+.10		+.11	-.13		-.12
S/ROLL	+.12		+.09	-.65		-.64	-.69		-.69
S/YAW	-.12		-.07	+.33		+.31	+.57		+.57
POWSET	+.26		+.25	+.28		+.26	+.27		+.28
ALTERR	-.08		-.10	-.03		-.02	+.03		+.04
CXERR	-.01		-.01	+.00		+.01	+.15		+.15
SACCLM		+.25	+.06		+.32	+.10		+.27	-.01
SACCLS		-.31	-.00		-.42	-.06		-.36	+.01
DWELLM		-.27	+.09		-.36	-.06		-.43	-.05
DWELLS		+.29	-.12		+.25	-.01		+.32	-.00
FIXRATE		+.82	+.25		+.72	-.01		+.71	-.10
BLINKR		+.10	-.10		+.07	+.01		+.07	-.01
PUPILD		+.06	-.01		+.04	.00		+.04	+.02

Opinion scores were positively weighted in the first and third segments, and negatively weighted in the second segment.

- D_v, formed from visual response data, produced highly consistent weightings across segments. Fixation rate dominated in all three segments although other variables were strong contributors (that is, SACCLM, SACCLS, DWELLM, DWELLS).
- D_{pv}, formed from both visual response and flight performance data, shows clear dominance by the performance data scores. Magnitudes of the discriminant weights for performance variables were relatively unchanged, while the visual response weights drop drastically. Fixation rate remained a relatively strong contributor to the approach function.

All of the discriminants significantly separated the 18 conditions in the 3 x 3 x 2 design. Data was collapsed over subjects and replications for this analysis, giving 30 data points for each condition ($p \leq .01$ as evaluated by Rao's criterion).[21]

Condition Centroids--The effect of multiple discriminant analysis on the data with respect to its ability to separate different experimental conditions can be observed by plotting the various condition centroids on the resultant discriminant scale. Centroids correspond to means of each condition on the discriminant scale. They are computed by multiplying the mean of each variable for a given condition by the discriminant weight for that variable. The resultant values are summed to form the condition centroid.

Figures 13 and 14 show the distribution of centroids. Figure 13 shows the distribution of the entire 18 experimental conditions on discriminant scales D_p and D_v. The figure shows that:

- The flight performance based discriminant, D_p, separates different wind conditions and generally does not separate display/motion conditions. Some separation of F-DIR from the other displays was evident in approach and deceleration segments. These results are generally consistent with the univariate tests on the flight performance variables. The grand centroids for the three wind conditions are shown in Figure 14.

- The visual response discriminant, D_v, separates motion and display conditions. Note that moving base conditions are generally positive in value on this scale, while fixed base conditions fall below 0. The GRAPHIC II display conditions with motion tend to be grouped at the low end of the scale. This is consistent with the univariate interactions discussed above. This moving vs. fixed base differentiation is clearly projected in the grand centroids for D_v, shown in Figure 14. The nine moving and nine fixed base conditions are completely separated by the horizontal line in the three segments.

Within a motion condition, there is also clear discrimination between display conditions. F-DIR and GRAPHIC I displays were about equal, and GRAPHIC II was distinctly different. The difference between these display centroids was not as pronounced in the motion base condition, however.

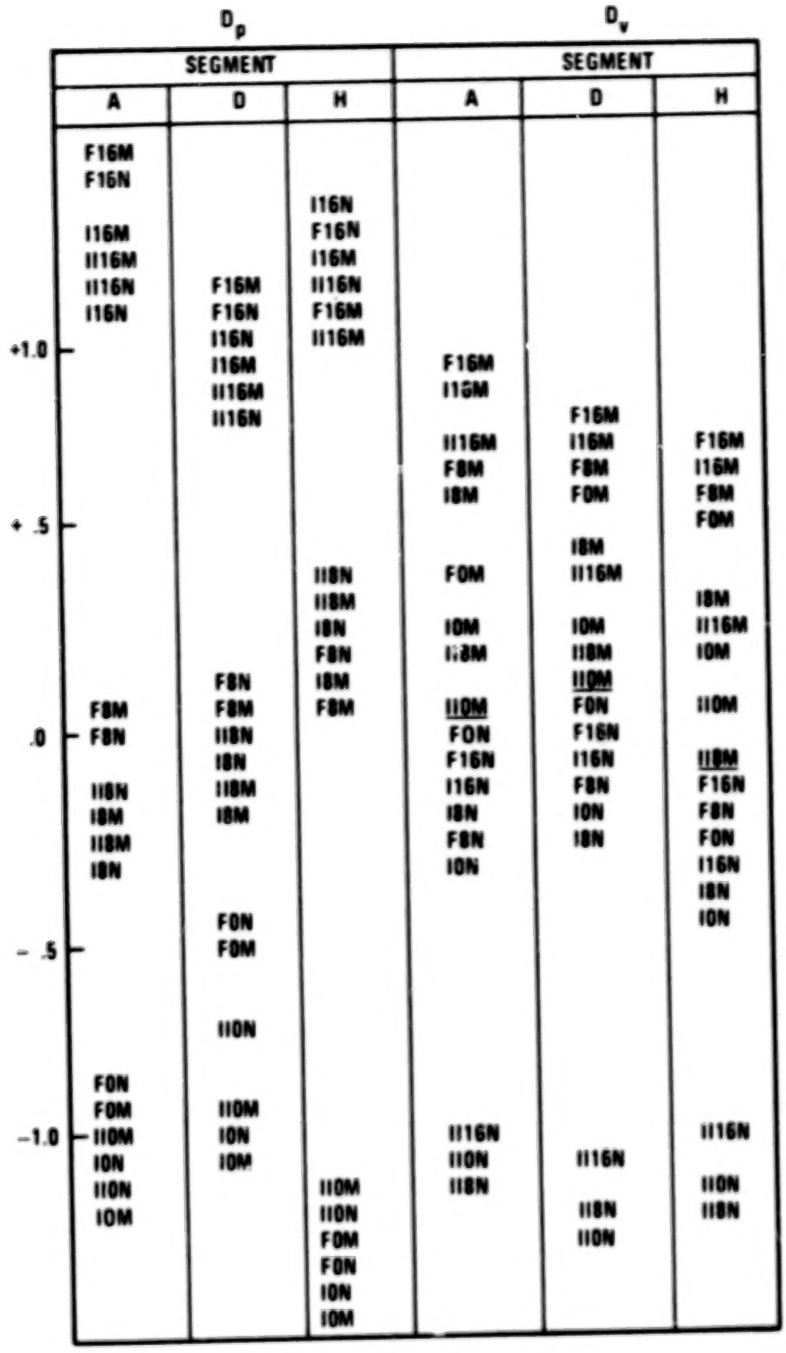

Figure 13. Group Centroids for D_p and D_v (Note: First designator indicates displays: F = F-DIR, I = GRAPHIC I, II = GRAPHIC II; second designator indicates wind: 0 = 0/0, 8 = 8/4, 16 = 16/8; and third designator indicates motion: M = moving, N = fixed base.)

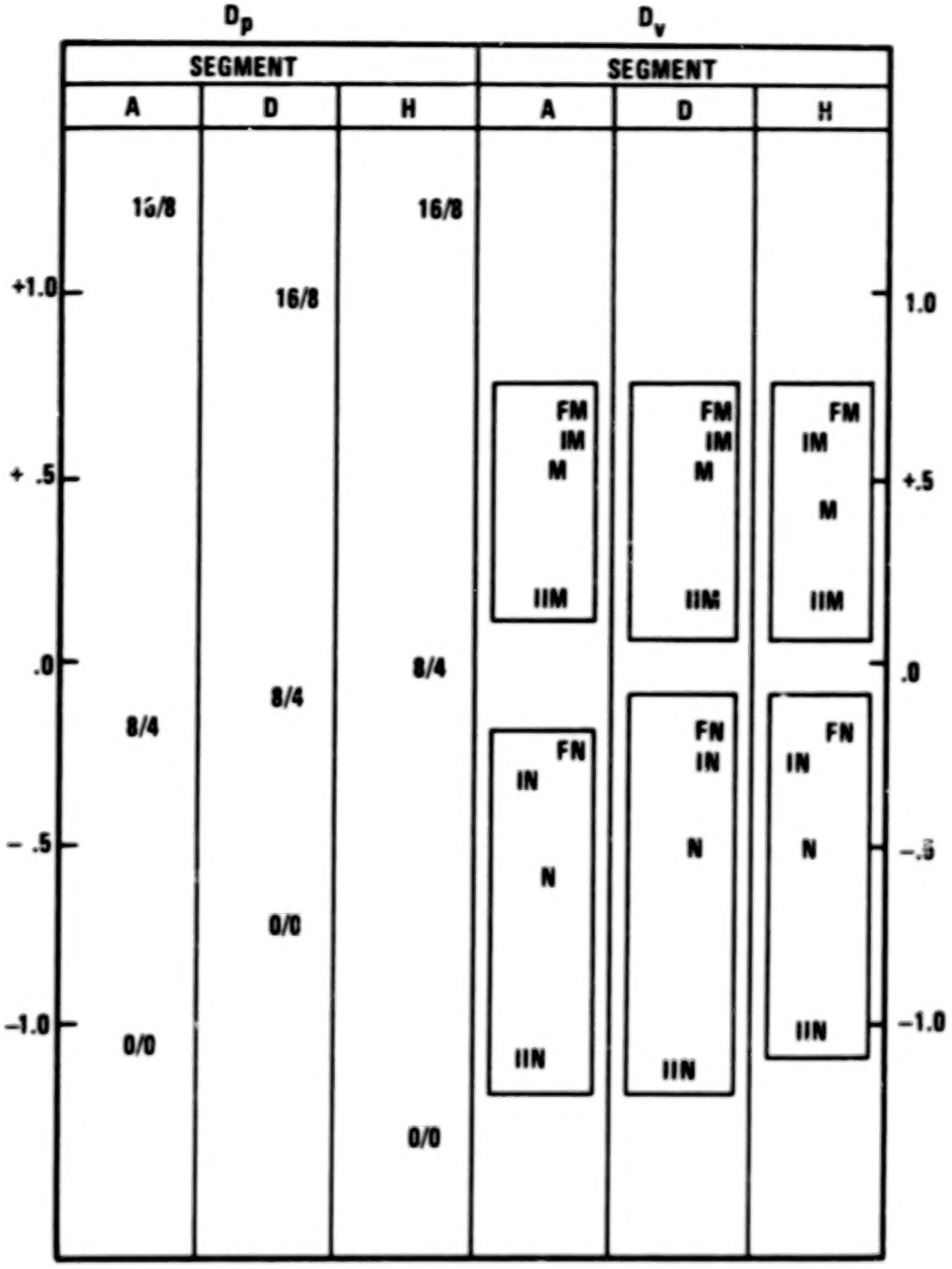

Figure 14. Grand Centroids for Wind Conditions in D_p and Motion Base/ Display Conditions in D_v (Note: M and N indicate position of grand centroids for moving and fixed base; F, I, and II prefixes are display centroids for the indicated motion base condition.)

Multiple Regression

Three prediction cases will be presented out of the five indicated in Section 3.

- Physiological measures plus oculometer measures predicting D_p (flight performance/opinion score discriminant)
- Physiological measures predicting D_v (visual data discriminant)
- Physiological measures predicting the combined discriminant D_{pv}, formed from both flight performance/opinion and oculometer measures

The remaining two cases are not presented because they either produced nearly identical results with one of the above (physiological predicting D_p) or did not produce significant prediction equations (oculometer measures predicting D_p).

Table 8 shows the prediction coefficients obtained in the stepwise analyses. A blank entry indicates either removal or non-entry of that predictor variable into the equation.

Several features of these prediction weights are evident:

- For all cases, there are few inconsistencies in weightings across flight segments for the largest contributors.
- Considering the D_p discriminant as our criterion, high D_p scores are produced by: 1) high left EMG activity amplitude with low standard deviation (EMGALM, EMGALS), 2) low respiration amplitudes with high standard deviation (RESAMP, RESAMS), 3) low duration heartbeat, for example, high rates (ECGRDM), 4) low ECGS/R ratios, high "p" intervals (ECGPIN), 5) high fixation rates (FIXRATE), and 6) high pupil diameter score (PUPILD).

Table 8. Standardized Multiple Regression Coefficients

	Approach			Deceleration			Hover		
Variable	D_p	D_v	D_{pv}	D_p	D_v	D_{pv}	D_p	D_v	D_{vp}
ENGARM	0.02	0.14	0.01	0.22	0.19	0.25	-0.07	0.35	-0.10
EMGARS	-0.07	-0.16	-0.08	-0.08	-0.07	-0.10	0.10	-0.12	0.08
EMGALM	0.56	-0.04	0.53	0.46		0.39	0.44	-0.26	0.46
EMGALS	-0.46	0.07	-0.44	-0.57	-0.12	-0.50	-0.26	0.08	-0.33
RESAMP	-0.15	0.09	-0.13	0.04	0.09	0.09	-0.16	-0.07	-0.14
RESAMS	0.24	0.04	0.21	0.15	0.05	0.14	0.19	0.15	0.20
RESPDM	0.03	-0.32	-0.05	-0.14	-0.29	-0.16	0.08	0.02	0.07
RESPDS	-0.14	0.27	-0.05	0.08	0.26	0.10	-0.09	0.03	-0.12
ECGRAM	0.07	-0.09	0.07	-0.14	-0.21	-0.15	-0.11	-0.16	-0.07
ECGRAS	0.04	-0.00	0.03		0.04		0.01	0.13	0.02
ECGRDM	-0.15	0.03	-0.15	-0.06	0.09	-0.05	-0.20		-0.23
ECGRDS	-0.02	0.04	0.00	0.01	0.06	0.04	0.06	0.17	0.05
ECGP/R	0.07	0.12	0.07	0.08	0.03	0.07	0.02	0.24	
ECGQ/R	-0.01	0.14		0.04	0.17	0.01	0.08	0.20	-0.02
ECGS/R	-0.14	-0.09	-0.13	-0.17	-0.08	-0.17	-0.09	-0.21	-0.10
ECGT/R	0.11	0.03	0.14	0.11	0.07	0.16	0.23	0.18	0.26
ECGPIN	0.16	0.07	0.19	0.12	0.10	0.15		0.10	0.02
ECGQIN		0.18	0.03	0.12	0.08	0.10	0.02	0.15	
ECGRIN	0.11	-0.01	0.06	0.07	-0.08	0.07	-0.10	-0.08	-0.06
ECGSIN	0.06	0.01	0.04	0.10	-0.08	0.08	0.05	-0.13	0.08
ECGTIN	0.19	0.18	0.18	0.02	0.26	0.07	-0.02	0.27	
SACCLM	0.16			0.12			0.05		
SACCLS	-0.07			-0.16			-0.19		
DWELLM	0.14			0.11			0.06		
DWELLS	-0.06						0.01		
FIXRATE	0.18			0.14			0.14		
BLINKR	0.13			-0.06			-0.00		
PUPILD	0.14			0.15			0.18		
R	.41	.43	.33	.40	.45	.37	.31	.50	.27

- Considering the D_v prediction case as our criterion, high scores are produced by: 1) high right arm EMG amplitude and low standard deviations (EMGARM, EMGARS), 2) low left arm EMG amplitude during hover (EMGALM), 3) low respiration rate with high values of standard deviation (RESPDM, RESPDS), 4) low amplitude heartbeat (ECGRAM) in deceleration and hover, and 5) high ECGQ/R ratio and low ECGS/R ratio, high ECGQIN, and high ECGTIN values.

The interpretation of the weightings is primarily speculative although several of the weights in case D_p above are logical. Recalling that D_p is highly sensitive to the wind condition changes acting as the difficulty forcing function, it appears that high workload level is characterized by high muscle activity, high heart rate, irregular respiration rate, high fixation rate (more fixations per time interval), and high pupil diameter.

Several of the predictors change magnitude, and in some cases sign in the D_v equation during the hover segment. This result suggests that the operational requirements in hover, particularly in the acquisition strategy for visual information, may be different.

The multiple regression coefficients, although statistically significant, appear to be rather low. It must be remembered that the data submitted to this analysis included variance caused by the five replications for each subject. Day-to-day changes in performance caused by motivation, fatigue, etc., contribute to this variance. If this variance were removed by collapsing across replications, the predictive power of the equations would appear substantially higher.

Predictive Relationships--The relationship between the scores attained on the discriminant scales and scores predicted by the physiological variables is the basis for examining the capability of physiological measures to measure workload. For the D_p, the discriminant scale can be interpreted as a scale of task difficulty because wind amplitude conditions were maximally separated by these variables. In Figure 15, we have plotted the centroids of the 18 conditions on D_p against the 18 centroids predicted using the regression coefficients and the physiological variables. Note that the three wind conditions are clearly separated by the D scale, as indicated earlier. The three lines indicate the consistent linear relationship between the physiological measures and the performance measures across these changes in task difficulty.

Figure 16 shows a similar relationship. However, as previously indicated, the D_v maximized differences between motion conditions. The physiological scale maintains the general separation between motion and fixed base conditions. Grand centroids have been plotted to highlight this feature.

Opinion Data--Because opinion data was collected only in the display/motion combinations and not evaluated for the three wind conditions, its overall applicability is somewhat limited in the present experiment. The mean ratings across the six subjects are presented in Table 9.

Although an analysis of variance was not performed on this data due to the small sample size, it is evident that the GRAPHIC I display was considered to be the least demanding on workload for the three displays compared. Although subjects were inconsistent in their ratings of F-DIR and GRAPHIC II displays, they consistently gave the GRAPHIC I display a lower workload rating than the other two displays.

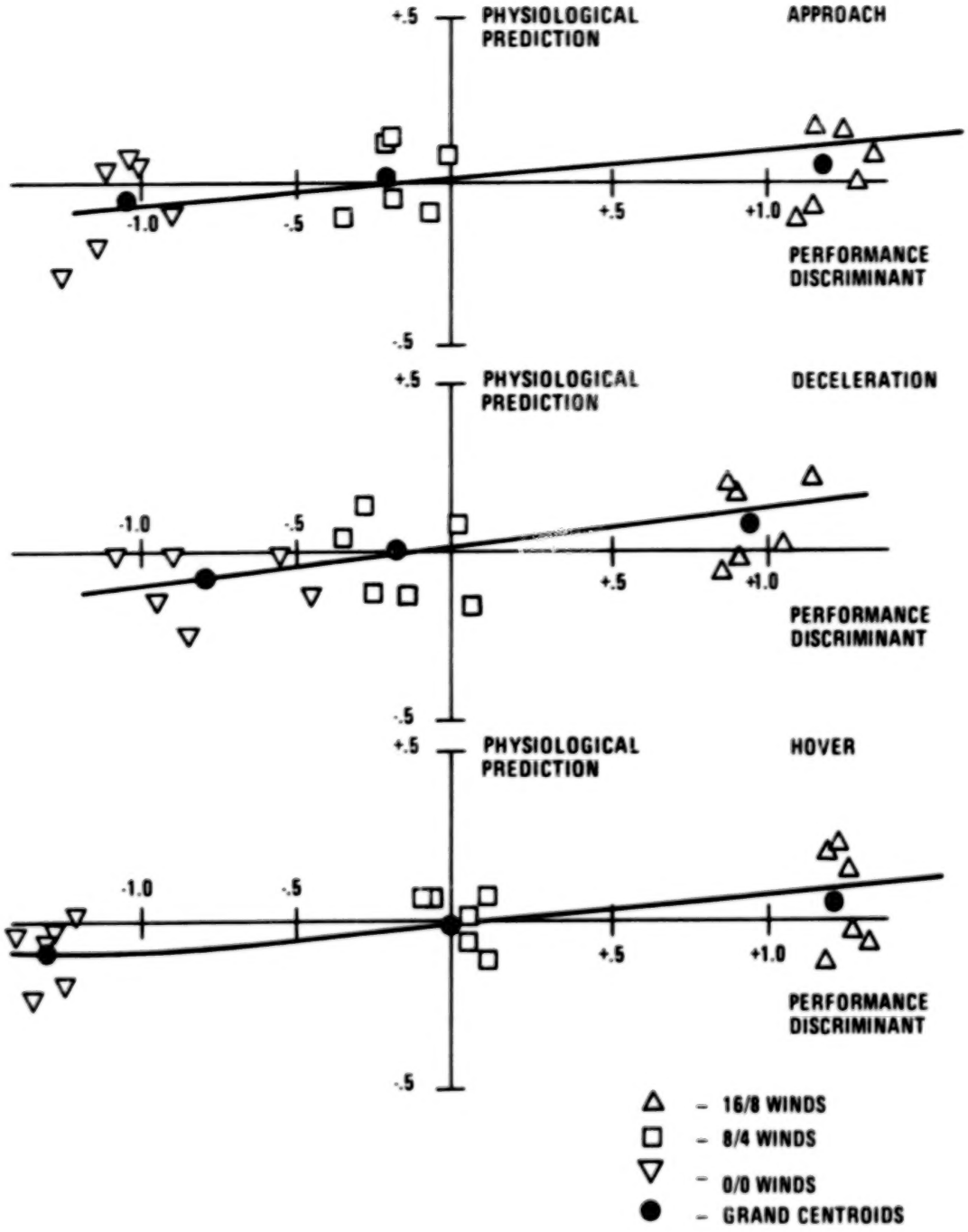

Figure 15. Prediction of Workload (Performance Discriminant) by Physiological Variables Showing Position of Predicted vs. Actual Condition Centroids

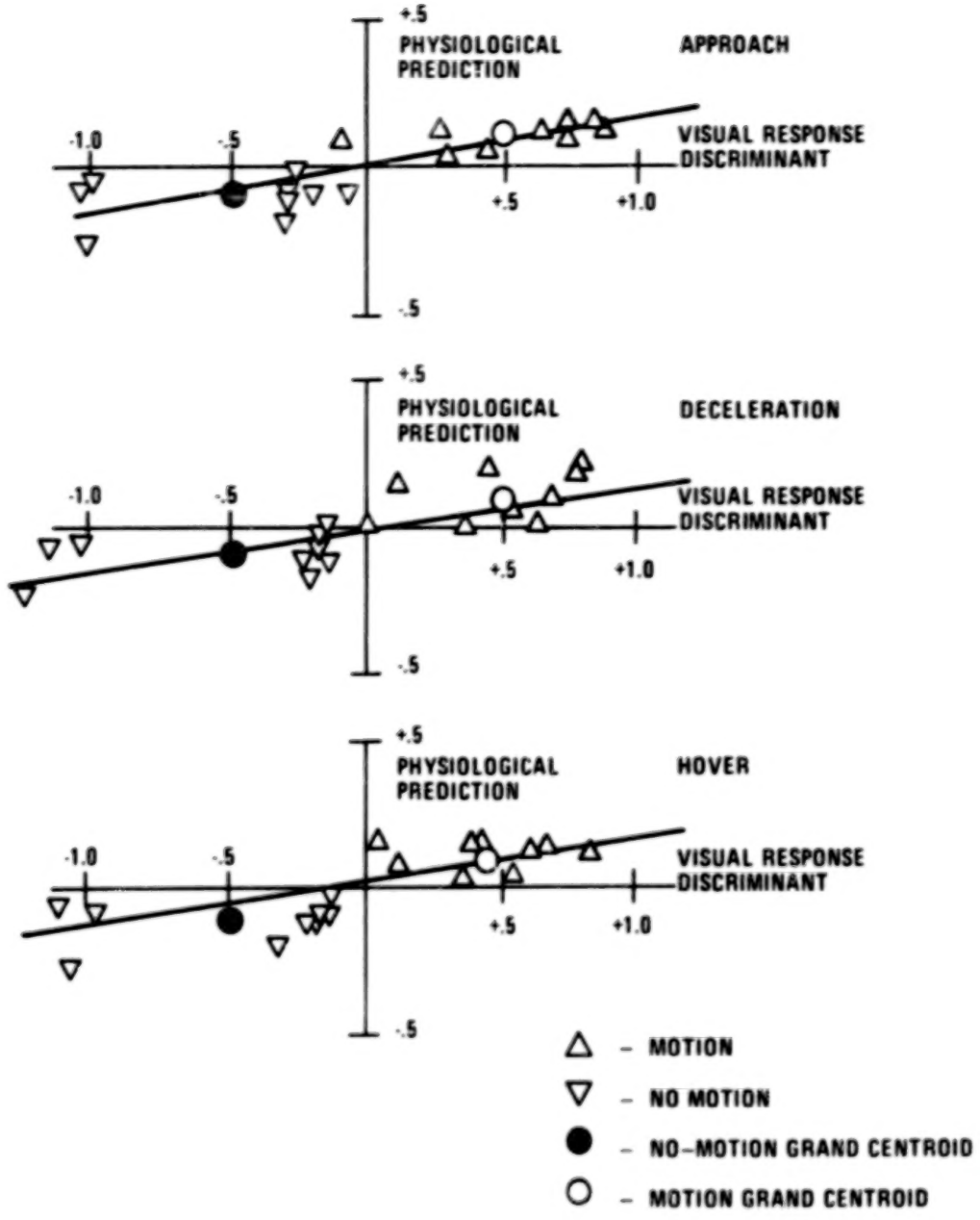

Figure 16. Prediction of Visual Response Measure Discriminant by Physiological Variables Showing Positions of Predicted vs. Actual Condition Centroids

Table 9. Workload Opinion Data Means Over Motion/Display Combinations

	Displays		
	GRAPHIC I	GRAPHIC II	F-DIR
Moving base	3.95	5.33	5.38
Fixed base	4.20	5.75	6.04

Motion base evaluation demonstrated a small but consistent preference in favor of the motion base condition.

Appendix C contains raw data for the rating scales across subjects, motion, and display conditions.

Opinion data corresponded with general order-of-merit findings within display conditions assessed by the flight performance measures. GRAPHIC II was considered to impose highest workload compared to the other displays, and this is partially substantiated by several flight performance scores. Order-of-merit between GRAPHIC II and F-DIR displays was unclear in both opinion and flight performance scores, however.

Workload estimation of moving vs. fixed base conditions were, as indicated, less clear. Performance data also showed generally non-significant differences between fixed base and motion base conditions.

SECTION 5

CONCLUSIONS

The results of this study have demonstrated the success of applying physiological measures as predictors of workload provided with comparative data related to flight performance with conventional and graphic VTOL landing displays, suggested utility for both visual response data, and pilot opinion scores.

Workload Prediction

This study provides further support for the predictive relationship between physiological measures and workload level. Multiple discriminant analysis was successfully applied to conventional flight performance scores deriving a scale that produced maximum separation of conditions known to impose different workload levels. Stepwise multiple regression revealed physiological measures that successfully predicted scores on this scale. Visual response scores did not add new information to this predictive relationship. A summarization of the prediction equations for the three flight segments is shown in Table 10. The major coefficients are included for each segment.

EMG Measures--EMG left arm amplitude and deviation appear to be important predictors of workload in VTOL approaches. This relationship appears consistent across all three flight segments. High activity (arm tension) with low deviation indicates a high workload condition. This result is not surprising, since the left arm was controlling altitude performance. Therefore, left arm EMG may be a specific predictor associated with landing tasks of this sort.

Table 10. Major Regression Weights for Workload Prediction from Physiological Variables

	Approach	Deceleration	Hover
EMGALM	+.53	+.39	+.46
EMGALS	-.44	-.50	-.33
RESAMP	-.13		-.14
RESAMS	+.21	+.14	+.20
RESPDM		-.16	
ECGRAM		-.15	
ECGRDM	-.15		-.23
ECGS/R	-.13	-.17	
ECGT/R	+.14	+.16	+.26
ECGPIN	+.19	+.15	
ECGTIN	+.18		

Respiration Measures--In approach and hover, high workload is indicated by shallow (low amplitude) and irregular (high deviation) breathing, and in deceleration by a higher respiration rate.

ECG Waveforms--Amplitude of the ECG waveform was negatively related to workload only in the deceleration segment. The duration was negatively related in the approach and hover segments. Heart rate, therefore, appears positively related to workload in these segments.

Low ratios of R to S amplitudes in the ECG wave suggest high workload in approach and deceleration, as does high T to R duration (all segments), and P interval (approach and deceleration). Longer T intervals suggest high workload in approach to landing only.

Thus, physiological variables showed an order-of-merit with respect to consistency across segments. EMG measures appear to be most generalizable across flight situations, followed by respiration measures, and ECG waveform measures. In general, this result is consistent with previous workload studies in this series.[4, 5, 6, 7, 8]

Visual Response Data

Visual response measures appear highly sensitive to both display and motion base conditions, as indicated by the examination of individual measures and multivariate discriminant analyses. In general, the moving base condition is characterized by frequent eye movements, while the fixed base condition tends to slow movement down and increase dwell time. The effect of displays on these measures is consistent. The GRAPHIC II display exhibits different visual response under the fixed base condition; pilots are required to make more frequent shifts in visual attention (higher fixation rate, low dwell times). The GRAPHIC II display is also characterized by shorter movements of the eyes over both motion conditions.

It is difficult to relate the special properties of these visual measures to workload level because little is actually known of the relationship from previous work. It is concluded, however, that visual response data can be of interest in determining the special visual data acquisition strategies used by pilots in different flight situations.

Display Comparisons

The following conclusions are made concerning the three displays evaluated in this study:

- Displays were different with regard to performance as measured by conventional flight performance variables. These differences, however, were not consistent in their orders of merit. Motion tended to attenuate the display differences.
- Displays were not well discriminated by physiological measures suggesting difficulty in the use of such measures to determine the workload imposed by different displays.
- Displays were well discriminated by visual response data as indicated previously. Again, motion lessened the effect of the three display conditions.

With regard to the particular orders of merit of the three displays tested in this study, the following conclusions and recommendations are offered:

- The conventional flight director is superior to graphically produced displays for maintaining pitch command and altitude command (especially during hover). The flight director is also better for maintaining airspeed command. The flight director is clearly inferior to the graphic type displays in maintaining heading command.
- GRAPHIC I and flight director displays are superior to the GRAPHIC II display in maintaining altitude command.

- The GRAPHIC I display shows clear superiority to the other two displays in maintaining roll commands. It is also better at maintaining crosstrack in hover. Thus, the GRAPHIC I display seems to efficiently combine needed information although possible improvement could be offered in presenting airspeed and/or pitch command information.

Motion Base Effects

Although the results of this study are unclear regarding the special workload properties of motion vs. no motion in the simulator as measured by physiological variables, several relationships are clear:

- Motion causes more arm movement, larger S amplitudes on ECG, larger respiration-amplitude values, and lower ECG R interval values.
- Motion tends to produce more accelerations during flight as would be expected. The relationship between error scores and motion is less clear with about the same performance for moving and fixed base cases. Crosstrack errors in hover were much less with the motion base condition, although this was the only strong effect produced.
- Visual responses of pilots are extremely different in moving vs. fixed base operation. The special properties of these responses were discussed previously.

Opinion Scores

The Cooper-Harper method of rating workload was in general agreement with performance data on these displays. The six pilots in this study showed preference for the GRAPHIC I and F-DIR displays over GRAPHIC II. Because wind workload was not rated and segment ratings were combined, it is difficult to draw strong conclusions regarding the utility of opinion scores in this study.

APPENDIX A

CELL MEANS

SEGMENT 1 VARIABLE 1 EMGARM

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	15.2064	16.1269	15.5010
	6.5427	6.9298	6.1021
8/8	15.0552	15.7599	15.2723
	5.9298	6.1079	5.7549
16/8	15.1233	16.3330	15.0084
	5.7826	6.2181	4.6873

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	16.3918	18.0330	16.9017
	7.1124	8.9223	6.1164
8/8	16.2275	19.0598	15.7796
	5.5345	8.4552	4.7357
16/8	17.8282	20.0369	18.6192
	6.0485	7.7725	5.2893

SEGMENT 1 VARIABLE 2 EMGAKS

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	10.5191	11.6249	10.4914
	4.6655	4.7497	4.2603
8/8	10.2505	10.7666	10.7328
	4.2548	4.5994	4.6818
16/8	10.6325	11.3269	10.5823
	4.4032	4.6169	3.9135

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	10.9243	12.2791	11.4911
	5.2231	6.3403	4.6560
8/8	10.9195	12.6241	11.0517
	4.3942	5.6640	3.5137
16/8	12.0653	13.7836	12.6237
	4.4848	5.4674	3.8263

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SEGMENT 1 VARIABLE 4 ENGALM

MUTION = NO

	GRAPH I	GRAPH II	F-DIF
O/O	9.8187	10.4504	9.0608
	4.5435	4.5856	2.7694
R/A	10.1550	10.6714	8.4734
	4.4503	4.8859	3.0578
16/8	11.2127	11.8508	10.2280
	5.1402	5.6242	3.5704

MUTION = YES

	GRAPH I	GRAPH II	F-DIF
O/O	10.5120	11.4009	10.4454
	5.4100	5.5257	4.0324
R/A	11.5722	12.1313	10.5575
	5.5021	5.4009	4.1538
16/8	12.4089	13.5553	11.5314
	5.8577	7.7215	4.8480

SEGMENT 1 VARIABLE 5 ENGALS

MUTION = NO

	GRAPH I	GRAPH II	F-DIF
O/O	7.5495	8.0197	7.0253
	4.1892	4.3014	2.4956
R/A	7.7451	7.8857	7.2477
	4.1872	5.8400	3.4581
16/8	8.4187	8.8459	8.0207
	4.8814	4.8778	5.7320

MUTION = YES

	GRAPH I	GRAPH II	F-DIF
O/O	7.8844	8.4508	8.1093
	5.8554	4.8656	4.0035
R/A	8.0255	9.1180	8.5123
	4.8514	5.5218	5.7898
16/8	9.8984	10.8184	8.7684
	5.0530	8.4186	4.1154

SEGMENT 1 VARIABLE 7 RESAMP

MOTION = 0/0

	GRAPH I	GRAPH II	F-DIM
0/0	142.4883	144.8005	142.8160
	59.8482	58.1604	62.8345
8/4	137.6763	140.2194	141.4391
	49.6961	49.6008	52.3072
16/8	149.3504	139.6454	139.6454
	58.7142	42.4380	52.5740

MOTION = YES

	GRAPH I	GRAPH II	F-DIM
0/0	155.1052	150.8258	155.4841
	66.6102	61.0283	61.3548
8/4	150.3943	144.8268	149.4150
	58.0218	52.2683	52.9225
16/8	146.0271	146.3024	154.7920
	45.8884	43.3551	58.7019

SEGMENT 1 VARIABLE 8 RESAMS

MOTION = 0/0

	GRAPH I	GRAPH II	F-DIM
0/0	22.0103	20.2582	20.0712
	11.7852	11.9877	9.3853
8/4	22.9184	25.7189	27.3569
	11.2654	13.2320	14.5306
16/8	25.3043	22.5858	26.4813
	15.9545	8.2055	17.4248

MOTION = YES

	GRAPH I	GRAPH II	F-DIM
0/0	26.1540	24.5786	25.1054
	10.5105	14.1116	10.7122
8/4	27.1524	25.2083	24.9429
	15.6377	15.5758	26.7543
16/8	30.4085	26.2425	31.7660
	14.5707	10.5280	24.1208

SEGMENT 1 VARIABLE 9 RESPON

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	2.6625	2.6856	2.6499
	0.3140	0.3083	0.2432
8/8	2.6520	2.6140	2.6806
	0.3605	0.3245	0.3410
16/8	2.6570	2.5370	2.6111
	0.3274	0.2845	0.3570

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	2.6171	2.4651	2.5415
	0.3301	0.2660	0.2651
8/8	2.5002	2.5254	2.4941
	0.3571	0.3541	0.3266
16/8	2.5104	2.5017	2.4774
	0.3440	0.2742	0.3191

SEGMENT 1 VARIABLE 10 RESPDS

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.2625	0.2149	0.2888
	0.1809	0.1153	0.1604
8/8	0.2733	0.3410	0.3156
	0.1782	0.2957	0.2671
16/8	0.2580	0.2240	0.3064
	0.1477	0.1489	0.2028

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.3742	0.3185	0.3305
	0.2458	0.2977	0.2456
8/8	0.3401	0.3812	0.2901
	0.2887	0.2453	0.2188
16/8	0.3944	0.2475	0.2855
	0.6202	0.1371	0.2608

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SEGMENT 1 VARIABLE 13 EOGRAM

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	244.3571	243.0858	244.2068
	97.2290	97.1083	97.3518
8/4	242.2832	241.9905	242.5253
	95.7932	92.7979	96.6356
16/8	244.5755	243.6366	240.2243
	95.6142	94.4017	94.0532

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	245.0108	248.9073	250.6556
	95.8467	96.4840	97.6081
8/4	243.7814	244.7865	244.5066
	94.9806	94.3105	96.0142
16/8	243.0072	241.9210	244.3834
	93.6618	91.9546	94.5032

SEGMENT 1 VARIABLE 14 EOGRAS

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	19.0824	19.0594	16.2639
	19.7376	20.3818	19.1394
8/4	15.9279	25.4867	19.2847
	17.2591	27.3174	20.6356
16/8	16.5522	20.2852	19.8372
	18.0955	21.7846	20.1181

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	25.8621	21.4384	16.2133
	28.5140	21.7047	18.0155
8/4	19.6521	22.2896	21.5361
	22.0540	26.3004	24.6398
16/8	20.9043	23.5834	20.7343
	20.5592	23.6301	20.7422

SEGMENT 1 VARIABLE 15 EGGRDS

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.7256	0.7218	0.7371
	0.1035	0.0880	[illegible]
8/8	0.7201	0.7010	[illegible]
	0.0812	0.0746	[illegible]
16/8	0.7191	0.6980	[illegible]
	0.0806	0.0746	0.0865

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.7143	0.7134	0.7075
	0.1058	0.0907	0.1081
8/8	0.7046	0.6961	0.7006
	0.0852	0.0914	0.0945
16/8	0.6784	0.6847	0.6893
	0.0787	0.0767	0.0859

SEGMENT 1 VARIABLE 16 FEGRDS

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.0885	0.0887	0.0951
	0.0443	0.0550	0.0584
8/8	0.0879	0.0837	0.0768
	0.0459	0.0449	0.0369
16/8	0.0838	0.0832	0.0924
	0.0550	0.0327	0.0488

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.0744	0.0850	0.0780
	0.0452	0.0512	0.0377
8/8	0.0960	0.0885	0.0923
	0.0520	0.0536	0.0577
16/8	0.0778	0.1005	0.0897
	0.0444	0.0549	0.0580

SEGMENT 1 VARIABLE 17 ECGP/R

MOTION = [illegible]

	GRAPH I	GRAPH II	F-DIR
0/0	0.0078	0.0198	0.0104
	0.0512	0.0356	0.0249
8/4	0.0112	0.0112	0.0101
	0.0329	0.0298	0.0317
16/8	0.0103	0.0086	0.0123
	0.0341	0.0249	0.0318

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.0164	0.0159	0.0146
	0.0351	0.0324	0.0334
8/4	0.0152	0.0216	0.0194
	0.0324	0.0365	0.0358
16/8	0.0202	0.0149	0.0161
	0.0357	0.0310	0.0374

SEGMENT 1 VARIABLE 18 ECGG/R

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	-0.1451	-0.1501	-0.1464
	0.0714	0.0768	0.0700
8/4	-0.1482	-0.1451	-0.1460
	0.0748	0.0682	0.0677
16/8	-0.1455	-0.1589	-0.1456
	0.0585	0.0669	0.0670

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	-0.1445	-0.1518	-0.1498
	0.0615	0.0686	0.0649
8/4	-0.1475	-0.1492	-0.1476
	0.0655	0.0664	0.0613
16/8	-0.1459	-0.1491	-0.1551
	0.0616	0.0638	0.0648

SEGMENT 1 VARIABLE 20 FCGS/R

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	-0.1711	-0.1710	-0.1749
	0.0600	0.0659	0.0649
8/8	-0.1766	-0.1725	-0.1720
	0.0649	0.0592	0.0624
16/8	-0.1717	-0.1750	-0.1705
	0.0565	0.0568	0.0568

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	-0.1727	-0.1745	-0.1740
	0.0639	0.0658	0.0613
8/8	-0.1785	-0.1761	-0.1826
	0.0652	0.0671	0.0638
16/8	-0.1850	-0.1850	-0.1831
	0.0673	0.0700	0.0672

SEGMENT 1 VARIABLE 21 ECGI/R

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.1484	0.1478	0.1480
	0.0750	0.0785	0.0700
8/8	0.1551	0.1557	0.1482
	0.0636	0.0660	0.0635
16/8	0.1508	0.1541	0.1555
	0.0625	0.0609	0.0692

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.1425	0.1490	0.1368
	0.0536	0.0641	0.0595
8/8	0.1440	0.1408	0.1434
	0.0585	0.0591	0.0564
16/8	0.1520	0.1499	0.1481
	0.0562	0.0560	0.0698

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SEGMENT 1 VARIABLE 22 ECGPIN

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.0246	0.0364	0.0363
	0.0455	0.0590	0.0650
8/4	0.0483	0.0440	0.0540
	0.0654	0.0645	0.0777
16/8	0.0503	0.0586	0.0626
	0.0755	0.0813	0.0774

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.0516	0.0541	0.0603
	0.0741	0.0698	0.0761
8/4	0.0681	0.0618	0.0635
	0.0740	0.0734	0.0737
16/8	0.0549	0.0604	0.0678
	0.0764	0.0720	0.0777

SEGMENT 1 VARIABLE 23 ECGQIN

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.1864	0.1853	0.1957
	0.0955	0.0965	0.0935
8/4	0.1856	0.1697	0.1858
	0.0964	0.0935	0.0959
16/8	0.1852	0.1775	0.1860
	0.0967	0.0986	0.0959

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.1822	0.1857	0.1790
	0.0950	0.0938	0.0965
8/4	0.1776	0.1772	0.1753
	0.0978	0.0942	0.0952
16/8	0.1712	0.1804	0.1831
	0.0942	0.0972	0.0990

SEGMENT 1 VARIABLE 24 ECGRIN

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.0394	0.0391	0.0389
	0.0057	0.0057	0.0056
8/4	0.0397	0.0390	0.0393
	0.0051	0.0055	0.0065
16/8	0.0389	0.0389	0.0390
	0.0056	0.0056	0.0056

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.0386	0.0384	0.0382
	0.0057	0.0056	0.0055
8/4	0.0380	0.0385	0.0380
	0.0054	0.0069	0.0058
16/8	0.0376	0.0382	0.0378
	0.0058	0.0061	0.0059

SEGMENT 1 VARIABLE 25 ECGSIN

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.1505	0.1497	0.1486
	0.0401	0.0356	0.0351
8/4	0.1469	0.1472	0.1455
	0.0265	0.0266	0.0272
16/8	0.1447	0.1450	0.1455
	0.0245	0.0256	0.0270

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.1490	0.1476	0.1454
	0.0550	0.0557	0.0305
8/4	0.1440	0.1452	0.1447
	0.0265	0.0501	0.0257
16/8	0.1433	0.1427	0.1423
	0.0237	0.0255	0.0252

SEGMENT 1 VARIABLE 25 ECGIN

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.1282	0.1235	0.1280
	0.0375	0.0373	0.0328
8/8	0.1318	0.1282	0.1298
	0.0275	0.0285	0.0315
16/8	0.1319	0.1279	0.1300
	0.0282	0.0277	0.0280

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.1275	0.1258	0.1294
	0.0355	0.0360	0.0366
8/8	0.1273	0.1258	0.1263
	0.0334	0.0313	0.0344
16/8	0.1256	0.1257	0.1256
	0.0325	0.0338	0.0328

SEGMENT 1 VARIABLE 31 PITCH

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.0971	0.1084	0.0846
	0.0479	0.0402	0.0402
8/8	0.0967	0.1001	0.0707
	0.0523	0.0412	0.0280
16/8	0.1054	0.1207	0.0808
	0.0578	0.0471	0.0294

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.0841	0.1079	0.0680
	0.0458	0.0461	0.0259
8/8	0.0815	0.0948	0.0625
	0.0306	0.0336	0.0224
16/8	0.1152	0.1097	0.0682
	0.0762	0.0525	0.0275

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SEGMENT 1 VARIABLE 52 HOLE

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.1124	0.1404	0.1388
	0.0394	0.0554	0.0650
8/8	0.1501	0.1777	0.1521
	0.0411	0.0621	0.0659
16/8	0.1791	0.2296	0.1886
	0.0487	0.0849	0.0860

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.1254	0.1036	0.1439
	0.0631	0.0784	0.1024
8/8	0.1397	0.1888	0.1819
	0.0525	0.0862	0.1316
16/8	0.2183	0.2482	0.2482
	0.0854	0.0557	0.1306

SEGMENT 1 VARIABLE 53 FOURTH

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.3144	0.2868	0.2849
	0.1847	0.1384	0.1541
8/8	0.3477	0.3246	0.2946
	0.1603	0.1603	0.1545
16/8	0.3983	0.3882	0.3763
	0.1580	0.1385	0.1651

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.2741	0.2748	0.2683
	0.1459	0.1382	0.1602
8/8	0.3010	0.3057	0.2489
	0.1186	0.1582	0.1542
16/8	0.4108	0.4001	0.3548
	0.1618	0.1343	0.1453

SEGMENT 1 VARIABLE 54 HEADING

MOTION = rG

	GRAPH I	GRAPH II	F-DIR
0/0	0.1961	0.2099	0.2602
	0.0783	0.0714	0.1264
8/4	0.2214	0.2476	0.2698
	0.0525	0.1045	0.0969
16/8	0.3140	0.3511	0.3567
	0.0744	0.0875	0.0905

MOTION = YrS

	GRAPH I	GRAPH II	F-DIR
0/0	0.1548	0.1547	0.1717
	0.0516	0.0604	0.0862
8/4	0.1557	0.1860	0.1841
	0.0348	0.0435	0.0577
16/8	0.2702	0.2914	0.2740
	0.0626	0.0906	0.0742

SEGMENT 1 VARIABLE 55 ROLLAC

MOTION = sG

	GRAPH I	GRAPH II	F-DIR
0/0	2.3545	2.2384	3.1868
	0.6340	0.8528	1.1160
8/4	2.9305	3.2109	3.8809
	0.3543	0.5404	0.7918
16/8	4.8715	4.9971	5.6482
	0.6451	0.6549	0.8583

MOTION = YrS

	GRAPH I	GRAPH II	F-DIR
0/0	2.5462	2.9594	3.6139
	0.7213	1.5357	1.1486
8/4	3.5431	3.6123	4.6253
	0.8267	0.8460	1.3907
16/8	5.0047	5.0183	6.4901
	1.0879	1.1059	1.5167

SEGMENT 1 VARIABLE 56 PITCHAC

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.8194	1.0704	0.9264
	0.3718	0.3582	0.3701
8/8	0.8424	1.0311	1.0552
	0.3112	0.4335	0.4055
16/8	0.9827	1.4005	1.2807
	0.3057	0.6651	0.5298

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.6105	1.4001	1.4665
	0.3740	1.0951	0.8150
8/8	1.0095	1.3535	1.3676
	0.5057	0.7508	0.9161
16/8	1.4320	1.9717	1.9122
	0.7255	0.9818	1.0416

SEGMENT 1 VARIABLE 57 YAWACC

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	1.4754	1.3543	1.5486
	0.6071	0.4348	0.6143
8/8	2.4221	2.4928	2.6261
	0.5361	0.5588	0.8154
16/8	4.0304	4.2436	4.3224
	0.4220	0.5541	0.8727

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	1.3394	1.4755	1.4027
	0.4454	0.6507	0.6681
8/8	2.5748	2.4081	2.5592
	0.5242	0.2884	0.6546
16/8	4.1082	5.9420	4.2882
	0.7265	0.7188	0.8480

SEGMENT 1 VARIABLE 58 SPEEDEM

MOTION = NO

	GRAPH I	GRAPH II	T-DIR
0/0	5.0013	5.4944	2.4676
	1.5588	1.4722	1.2025
8/4	5.5755	5.5005	2.5112
	1.4503	1.5566	1.1009
16/8	5.1725	4.9123	4.1225
	5.7212	4.6741	2.6986

MOTION = YES

	GRAPH I	GRAPH II	T-DIR
0/0	4.7954	5.5209	3.1389
	4.7420	7.6688	1.7160
8/4	5.2454	6.1444	4.6054
	4.1521	5.9751	3.3028
16/8	7.8151	10.9213	4.6680
	5.5084	8.7927	2.9408

SEGMENT 1 VARIABLE 59 S/PITCH

MOTION = NO

	GRAPH I	GRAPH II	T-DIR
0/0	0.8150	0.8161	0.8155
	0.0075	0.0061	0.0053
8/4	0.8167	0.8167	0.8146
	0.0086	0.0129	0.0098
16/8	0.8174	0.8171	0.8205
	0.0167	0.0196	0.0190

MOTION = YES

	GRAPH I	GRAPH II	T-DIR
0/0	0.8158	0.8152	0.8150
	0.0065	0.0082	0.0061
8/4	0.8152	0.8143	0.8156
	0.0112	0.0141	0.0091
16/8	0.8145	0.8096	0.8134
	0.0269	0.0218	0.0142

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SEGMENT 1 VARIABLE 60 SMALL

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
O/O	1.1550	1.1455	1.1362
	0.0085	0.0056	0.0056
B/W	1.1305	1.1521	1.1352
	0.0089	0.0085	0.0058
16/8	1.1240	1.1294	1.1254
	0.0155	0.0150	0.0125

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
O/O	1.1302	1.1245	1.1554
	0.0102	0.0115	0.0085
B/W	1.1275	1.1280	1.1296
	0.0094	0.0113	0.0081
16/8	1.1194	1.1200	1.1268
	0.0167	0.0141	0.0106

SEGMENT 1 VARIABLE 61 STAR

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
O/O	0.7427	0.7415	0.7416
	0.0082	0.0082	0.0094
B/W	0.7307	0.7383	0.7400
	0.0092	0.0120	0.0087
16/8	0.7360	0.7304	0.7318
	0.0155	0.0178	0.0143

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
O/O	0.7332	0.7324	0.7372
	0.0123	0.0178	0.0080
B/W	0.7301	0.7355	0.7338
	0.0097	0.0135	0.0098
16/8	0.7212	0.7219	0.7357
	0.0185	0.0224	0.0134

SEGMENT 1 VARIABLE 42 POLSE1

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.2648	0.2657	0.2626
	0.0152	0.0186	0.0120
8/8	0.2729	0.2712	0.2648
	0.0199	0.0234	0.0151
16/8	0.2905	0.2837	0.2941
	0.0354	0.0420	0.0320

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.2742	0.2822	0.2703
	0.0250	0.0337	0.0178
8/8	0.2859	0.2871	0.2851
	0.0251	0.0340	0.0225
16/8	0.3016	0.3045	0.2894
	0.0508	0.0446	0.0315

SEGMENT 1 VARIABLE 43 ALIENN

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	20.6040	16.8588	18.2060
	20.8455	13.8758	12.9317
8/8	23.0288	21.5618	18.9362
	18.6480	17.8137	15.1047
16/8	26.6192	25.1588	25.0580
	19.8594	12.8743	20.0886

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	21.3488	18.1976	18.5543
	14.8752	14.8824	20.3824
8/8	17.7805	21.5574	21.2090
	10.0344	13.8824	14.8891
16/8	30.8584	26.2599	20.2810
	31.6201	17.7858	15.1285

SEGMENT 1 VARIABLE 43 CAENA

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	57.5063	50.4851	66.8368
	190.7544	12.7148	86.5018
8/8	55.1181	45.9362	45.2785
	10.0865	50.5508	33.2743
16/8	49.8177	52.2296	56.9928
	10.8681	158.4361	45.9131

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	42.7055	41.7730	68.8908
	44.8155	27.0135	88.5721
8/8	39.6884	40.7342	56.8363
	54.8448	27.2517	89.2965
16/8	58.8558	52.5198	66.4687
	83.2987	58.5177	76.8702

SEGMENT 1 VARIABLE 45 SACCLM

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	1.5421	1.5488	1.6405
	0.5218	0.6789	0.7100
8/8	1.5653	1.2323	1.6733
	0.4014	0.5404	0.5861
16/8	1.6845	1.2340	1.7484
	0.7918	0.4589	0.8311

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	1.5840	1.5850	1.7604
	0.5078	0.7191	0.7503
8/8	1.6670	1.5142	1.7806
	0.5444	0.7215	0.8365
16/8	1.7944	1.5011	2.0040
	0.8513	0.4885	0.9550

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SEGMENT 1 VARIABLE 46 SACCLS

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	1.4442	1.5767	1.4313
	0.6707	0.9334	0.6659
8/4	1.4960	1.3259	1.5359
	0.6300	0.8695	0.7995
16/8	1.5917	1.2991	1.5140
	0.6417	0.9954	0.7520

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	1.5580	1.4873	1.6519
	0.6456	0.8625	0.7504
8/4	1.6333	1.5946	1.6785
	0.6077	0.9032	0.7529
16/8	1.7411	1.5922	1.7971
	0.6682	0.6008	0.8975

SEGMENT 1 VARIABLE 47 DWELLM

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.5252	1.0781	0.5651
	0.1673	0.4187	0.4685
8/4	0.5041	1.0490	0.5047
	0.1404	0.7810	0.1281
16/8	0.5457	1.2412	0.5341
	0.2507	1.0623	0.2484

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.3990	0.5824	0.3830
	0.1513	0.3588	0.2512
8/4	0.3403	0.4340	0.2949
	0.1422	0.2249	0.0744
16/8	0.2869	0.3058	0.2799
	0.0663	0.1078	0.0672

SEGMENT 1 VARIABLE 44 DWELLS

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.5065	1.0571	0.5948
	0.2436	1.0060	0.8085
8/4	0.4755	1.0712	0.5048
	0.2005	0.7707	0.1913
16/8	0.5089	1.1771	0.5169
	0.3041	1.0048	0.2069

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.3335	0.5770	0.3447
	0.1619	0.5552	0.3051
8/4	0.2701	0.3844	0.2235
	0.1801	0.2795	0.0714
16/8	0.2177	0.2519	0.2069
	0.0875	0.1215	0.0721

SEGMENT 1 VARIABLE 44 FIXRATE

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	2.0865	1.3851	2.1130
	0.5774	0.8845	0.5892
8/4	2.1282	1.2952	2.0888
	0.5517	0.6006	0.5292
16/8	2.0899	1.3305	2.0953
	0.6565	0.7578	0.6687

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	2.8750	2.3554	2.9919
	0.7561	0.9113	0.7922
8/4	3.2618	2.8066	3.3462
	0.7521	0.9268	0.4973
16/8	3.4104	3.3547	3.4042
	0.3952	0.5317	0.4783

SEGMENT 1 VARIABLE 50 BLINKR

MOTION = [illegible]

	GRAPH I	GRAPH II	F-DIR
0/0	0.1555	0.1579	0.1100
	0.0957	0.1094	0.0911
8/4	0.1602	0.1484	0.1176
	0.1147	0.1358	0.0893
16/8	0.1725	0.1550	0.1281
	0.2000	0.1254	0.0987

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.2781	0.4077	0.3157
	0.2640	0.3512	0.3994
8/4	0.4744	0.5400	0.3673
	0.6349	0.6456	0.3471
16/8	0.6612	0.8858	0.6095
	0.3220	0.9096	0.3657

SEGMENT 1 VARIABLE 51 PUPILD

MOTION = [illegible]

	GRAPH I	GRAPH II	F-DIR
0/0	5.5603	5.9369	5.4335
	1.3127	1.4127	1.4042
8/4	5.5729	5.6401	5.4709
	1.1418	1.1443	1.2732
16/8	5.7320	5.9050	5.5855
	1.2002	1.1839	1.2632

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	5.3322	5.4279	5.3103
	1.3409	1.3528	1.3655
8/4	5.2887	5.2944	5.2075
	1.2707	1.2502	1.3259
16/8	5.3971	5.3802	5.3272
	1.1878	1.1500	1.3427

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SEGMENT 2 VARIABLE 1 EMGARM

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	15.7849	16.9211	16.8578
	7.1558	7.7315	7.1663
8/8	16.4281	17.2103	17.2959
	6.6223	7.0188	7.4224
16/8	16.9004	17.5168	17.1387
	7.0776	6.9071	6.8142

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	17.8192	19.6804	19.2847
	7.7534	9.0900	7.1149
8/8	18.9181	21.1861	18.6513
	8.7766	9.8104	5.9981
16/8	20.2775	22.0499	22.2690
	8.8773	9.8587	9.1463

SEGMENT 2 VARIABLE 2 EMGARS

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	10.8150	11.4781	11.2086
	5.1457	5.4625	4.8714
8/8	11.4494	11.5084	11.8531
	5.0521	4.8548	5.5329
16/8	11.5042	11.8546	11.6497
	5.0955	4.7490	5.0476

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	12.1082	13.0177	12.9857
	5.8855	6.3847	5.1177
8/8	12.7747	14.3488	12.8125
	6.5788	6.5142	4.4367
16/8	13.8655	14.9990	15.2927
	5.1145	7.1469	6.6348

SEGMENT 2 VARIABLE 4 ENGALR

MOTION = FO

	GRAPH I	GRAPH II	F-DIR
0/0	13.6059	14.9247	12.7932
	5.5324	6.3156	4.7391
8/4	14.1137	14.6789	15.2323
	6.5353	6.7582	5.1576
16/8	14.1625	15.3712	15.6667
	5.9308	7.6508	5.7229

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	15.7459	15.4806	14.5746
	7.3462	6.5125	6.8184
8/4	16.5026	16.9997	15.2046
	8.5685	8.6832	8.1123
16/8	16.4047	17.2097	15.8489
	8.1561	8.7816	9.0272

SEGMENT 2 VARIABLE 5 EMGALS

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	11.0203	11.5265	10.3260
	5.1042	5.2549	4.2984
8/4	10.5695	11.1294	10.9591
	4.9045	5.3320	4.5867
16/8	10.9551	11.5421	10.4316
	4.8878	5.4158	4.5293

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	12.5585	11.9212	11.3296
	6.5416	5.5798	5.5775
8/4	12.7806	13.0054	11.6464
	6.5547	6.8815	6.2721
16/8	12.4042	12.7894	12.0439
	6.1703	7.0520	6.5332

SEGMENT 2 VARIABLE 7 RESAMP

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	138.9896	139.7055	140.7150
	58.8759	54.1126	57.9160
8/8	135.0946	136.5592	135.2716
	48.5829	47.3096	46.7688
16/8	139.8074	140.7952	139.2892
	49.7955	48.3857	53.3682

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	140.4742	140.7389	144.1615
	57.5535	52.2468	54.7727
8/8	141.6179	136.7025	146.4150
	45.2196	45.3100	49.6558
16/8	141.3220	145.4686	150.1790
	42.2651	42.2429	48.3910

SEGMENT 2 VARIABLE 8 RESAMS

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	23.9818	19.4448	22.4647
	10.1754	7.8246	9.6692
8/8	22.2784	22.1290	22.1029
	9.5223	8.5865	11.3169
16/8	26.2575	24.4852	27.0535
	14.4865	13.0529	17.2493

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	24.4718	22.0115	24.6162
	13.7873	9.2356	14.4830
8/8	30.6304	27.5253	27.3847
	25.3346	15.9256	21.3073
16/8	25.8494	27.0703	29.6565
	10.9660	12.7480	20.0376

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SEGMENT 2 VARIABLE 9 RESPON

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
O/O	2.6101	2.5865	2.6025
	0.3070	0.3583	0.2459
R/A	2.5948	2.5050	2.5824
	0.3267	0.2718	0.2922
16/R	2.4997	2.4949	2.5194
	0.2857	0.2953	0.2645

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
O/O	2.4594	2.4113	2.4556
	0.2882	0.2692	0.3073
R/A	2.5372	2.4086	2.4043
	0.5487	0.5434	0.5111
16/R	2.3605	2.3625	2.3985
	0.4276	0.4722	0.5138

SEGMENT 2 VARIABLE 10 RESPOS

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
O/O	0.2129	0.2208	0.2225
	0.1791	0.1489	0.1351
R/A	0.2409	0.2481	0.2408
	0.1477	0.1809	0.1498
16/R	0.2241	0.2391	0.2609
	0.1269	0.1156	0.1496

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
O/O	0.2538	0.2470	0.2382
	0.1408	0.1687	0.1145
R/A	0.3546	0.3012	0.2689
	0.4782	0.2247	0.1936
16/R	0.3204	0.3171	0.3178
	0.5802	0.4006	0.4402

SEGMENT 2 VARIABLE 13 ECGRAM

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	244.9880	244.6176	244.9096
	96.7330	96.6030	96.3109
8/8	242.2010	243.6901	243.5673
	93.5528	94.1481	94.9148
16/8	243.7491	245.2549	239.2424
	94.0724	95.0506	91.4700

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	247.3397	249.9620	250.4233
	94.6051	96.0302	95.9581
8/8	247.0127	245.8747	246.5853
	95.5012	92.9531	94.9755
16/8	243.5441	243.9742	242.3014
	92.9078	92.3858	91.1287

SEGMENT 2 VARIABLE 14 ECGRAS

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	17.1219	17.7249	18.1633
	21.2487	19.5409	18.6070
8/8	22.3912	21.1142	20.5540
	22.9749	22.5081	21.5201
16/8	22.4723	15.9828	23.5500
	23.5859	17.9037	25.7499

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	21.9738	20.8576	17.9023
	25.7972	20.4055	24.8189
8/8	19.9767	25.4760	23.4700
	22.0468	26.2887	25.2937
16/8	19.5507	21.8866	26.5555
	20.5934	23.3402	28.9471

SEGMENT 2 VARIABLE 15 ECGRDM

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.7092	0.7000	0.7334
	0.0976	0.0775	0.0758
8/4	0.6984	0.6910	0.6968
	0.0815	0.0695	0.0961
16/8	0.7023	0.6939	0.6964
	0.0775	0.0798	0.0848

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.7079	0.6960	0.6949
	0.0973	0.0920	0.0929
8/4	0.6916	0.6936	0.6941
	0.0904	0.0900	0.0931
16/8	0.6794	0.6862	0.6727
	0.0891	0.0801	0.0853

SEGMENT 2 VARIABLE 16 ECGRDS

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.0794	0.0856	0.0962
	0.0446	0.0500	0.0593
8/4	0.0906	0.0912	0.0824
	0.0433	0.0529	0.0425
16/8	0.0920	0.0873	0.0896
	0.0552	0.0386	0.0544

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.0828	0.0852	0.0816
	0.0496	0.0472	0.0573
8/4	0.0900	0.1045	0.1070
	0.0521	0.0612	0.0681
16/8	0.0917	0.0972	0.1019
	0.0554	0.0682	0.0638

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SEGMENT 2 VARIABLE 17 ECGP/R

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.0111	0.0068	0.0079
	0.0284	0.0276	0.0300
8/4	0.0103	0.0149	0.0106
	0.0323	0.0278	0.0312
16/8	0.0129	0.0080	0.0144
	0.0301	0.0291	0.0288

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.0152	0.0151	0.0155
	0.0360	0.0336	0.0344
8/4	0.0148	0.0193	0.0131
	0.0337	0.0317	0.0296
16/8	0.0165	0.0171	0.0123
	0.0350	0.0291	0.0336

SEGMENT 2 VARIABLE 18 ECGV/R

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	-0.1456	-0.1464	-0.1469
	0.0705	0.0711	0.0696
8/4	-0.1470	-0.1432	-0.1468
	0.0667	0.0688	0.0647
16/8	-0.1443	-0.1521	-0.1455
	0.0664	0.0703	0.0645

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	-0.1446	-0.1533	-0.1493
	0.0609	0.0667	0.0647
8/4	-0.1477	-0.1468	-0.1532
	0.0623	0.0624	0.0662
16/8	-0.1577	-0.1523	-0.1563
	0.0687	0.0650	0.0719

SEGMENT 2 VARIABLE 20 ECGS/R

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	-0.1686	-0.1733	-0.1726
	0.0645	0.0653	0.0606
8/4	-0.1724	-0.1757	-0.1744
	0.0647	0.0625	0.0604
16/8	-0.1709	-0.1755	-0.1714
	0.0585	0.0603	0.0604

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	-0.1773	-0.1825	-0.1749
	0.0618	0.0635	0.0644
8/4	-0.1778	-0.1762	-0.1794
	0.0621	0.0635	0.0630
16/8	-0.1869	-0.1864	-0.1835
	0.0685	0.0688	0.0666

SEGMENT 2 VARIABLE 21 ECGT/R

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.1459	0.1479	0.1535
	0.0640	0.0706	0.0695
8/4	0.1533	0.1518	0.1510
	0.0680	0.0586	0.0622
16/8	0.1507	0.1593	0.1557
	0.0571	0.0673	0.0663

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.1423	0.1482	0.1420
	0.0601	0.0605	0.0593
8/4	0.1472	0.1440	0.1486
	0.0643	0.0647	0.0563
16/8	0.1465	0.1533	0.1483
	0.0686	0.0606	0.0647

SEGMENT 2 VARIABLE 22 ECGPIN

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.0387	0.0474	0.0485
	0.0589	0.0715	0.0673
8/4	0.0554	0.0515	0.0588
	0.0732	0.0705	0.0735
16/8	0.0535	0.0588	0.0656
	0.0738	0.0763	0.0763

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.0605	0.0495	0.0600
	0.0791	0.0640	0.0728
8/4	0.0619	0.0702	0.0631
	0.0754	0.0826	0.0695
16/8	0.0698	0.0658	0.0562
	0.0740	0.0736	0.0718

SEGMENT 2 VARIABLE 23 ECGQIN

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.1793	0.1854	0.1811
	0.0920	0.0961	0.0945
8/4	0.1853	0.1698	0.1827
	0.0965	0.0959	0.0946
16/8	0.1803	0.1918	0.1793
	0.0921	0.0962	0.0932

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.1860	0.1840	0.1813
	0.0930	0.0938	0.0955
8/4	0.1842	0.1759	0.1811
	0.0978	0.0919	0.0965
16/8	0.1801	0.1795	0.1834
	0.0972	0.0911	0.0959

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SEGMENT 2 VARIABLE 24 ECGRIN

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.0399	0.0393	0.0392
	0.0068	0.0061	0.0055
8/4	0.0391	0.0392	0.0391
	0.0056	0.0058	0.0055
16/8	0.0392	0.0389	0.0392
	0.0060	0.0057	0.0060

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.0386	0.0384	0.0387
	0.0054	0.0053	0.0056
8/4	0.0381	0.0384	0.0379
	0.0054	0.0060	0.0055
16/8	0.0382	0.0382	0.0382
	0.0064	0.0062	0.0061

SEGMENT 2 VARIABLE 25 ECGSIN

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.1464	0.1475	0.1470
	0.0315	0.0300	0.0279
8/4	0.1455	0.1453	0.1443
	0.0248	0.0245	0.0267
16/8	0.1446	0.1442	0.1455
	0.0260	0.0248	0.0266

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.1439	0.1448	0.1422
	0.0289	0.0284	0.0285
8/4	0.1432	0.1432	0.1419
	0.0252	0.0274	0.0237
16/8	0.1415	0.1411	0.1396
	0.0263	0.0237	0.0265

SEGMENT 2 VARIABLE 26 ECGTIN

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.1291	0.1244	0.1273
	0.0301	0.0269	0.0309
8/4	0.1288	0.1280	0.1292
	0.0278	0.0288	0.0291
16/8	0.1298	0.1269	0.1292
	0.0303	0.0259	0.0310

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.1263	0.1254	0.1262
	0.0408	0.0358	0.0330
8/4	0.1260	0.1243	0.1224
	0.0329	0.0334	0.0316
16/8	0.1246	0.1219	0.1253
	0.0348	0.0337	0.0334

SEGMENT 2 VARIABLE 31 PITCH

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.0848	0.1214	0.0864
	0.0379	0.0502	0.0489
8/4	0.1027	0.1410	0.0880
	0.0510	0.0520	0.0398
16/8	0.1457	0.1500	0.1050
	0.0620	0.0558	0.0401

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.1027	0.1233	0.0836
	0.0579	0.0514	0.0357
8/4	0.1099	0.1271	0.0921
	0.0504	0.0521	0.0362
16/8	0.1676	0.1438	0.0993
	0.1165	0.0513	0.0383

SEGMENT 2 VARIABLE 32 ROLL

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.0953	0.1211	0.1347
	0.0309	0.0505	0.0801
8/4	0.1376	0.1660	0.1503
	0.0508	0.0676	0.0536
16/8	0.1580	0.1946	0.1932
	0.0585	0.0665	0.1128

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.1077	0.1212	0.1271
	0.0584	0.0451	0.0883
8/4	0.1575	0.1784	0.1882
	0.0810	0.0586	0.1305
16/8	0.2182	0.2276	0.2303
	0.0884	0.0865	0.1035

SEGMENT 2 VARIABLE 33 POWER

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.1833	0.2219	0.1911
	0.0613	0.0961	0.0860
8/4	0.2173	0.2659	0.2104
	0.0885	0.1228	0.0780
16/8	0.3022	0.3698	0.3157
	0.1125	0.1655	0.2096

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.1886	0.2128	0.1677
	0.0747	0.0948	0.1010
8/4	0.2236	0.2850	0.1996
	0.0725	0.1658	0.0785
16/8	0.3405	0.3579	0.3228
	0.1621	0.1633	0.1504

SEGMENT 2 VARIABLE 34 HEADING

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.1780	0.2091	0.3155
	0.0720	0.0873	0.1510
8/4	0.2517	0.3078	0.3458
	0.0879	0.1236	0.1170
16/8	0.4479	0.4640	0.4865
	0.1007	0.1097	0.0960

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.1518	0.1590	0.2747
	0.0765	0.0587	0.1008
8/4	0.2141	0.2500	0.3133
	0.0832	0.0777	0.0895
16/8	0.4101	0.4491	0.4628
	0.1143	0.1352	0.1235

SEGMENT 2 VARIABLE 35 ROLLAC

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	2.5471	2.8212	3.8018
	0.8835	1.1427	1.3456
8/4	3.4027	3.8279	4.0854
	1.1973	1.7857	0.9339
16/8	4.7246	4.9439	5.6547
	1.1568	1.0466	1.1500

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	3.2122	3.5907	4.3950
	1.4166	1.8834	1.7243
8/4	3.8439	4.0140	5.0830
	1.1227	1.5920	1.6975
16/8	5.7663	5.4712	6.8142
	1.7600	1.5221	2.0619

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SEGMENT 2 VARIABLE 36 PITCHAC

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	1.1121	1.2962	1.3183
	0.3615	0.5093	0.5095
8/4	1.1324	1.9312	1.4606
	0.4631	1.7247	0.6726
16/8	1.3760	1.8900	1.8613
	0.5513	1.2866	0.7712

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	1.5666	1.8674	2.0545
	1.2454	1.3630	1.1525
8/4	1.6536	2.1172	2.1686
	1.1551	1.4815	1.0158
16/8	2.1245	2.4831	2.8941
	1.2314	1.6263	1.8236

SEGMENT 2 VARIABLE 37 YAWACC

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	2.6627	2.8448	3.7617
	1.2188	1.7396	3.9739
8/4	3.6492	4.3645	3.5088
	1.9782	2.7224	1.8985
16/8	5.0998	4.8065	5.0276
	2.1373	2.1683	2.2779

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	2.2572	2.0376	2.4507
	1.1860	0.6970	1.4468
8/4	2.6740	2.8872	3.4285
	0.6502	1.0247	1.8959
16/8	4.3418	4.3937	4.2128
	1.0197	1.9116	0.9647

SEGMENT 2 VARIABLE 38 SPEEDER

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	2.4483	3.6697	3.2357
	1.2600	1.5221	3.2355
8/4	3.2497	4.3396	2.7101
	3.5701	2.9410	1.8901
16/8	4.2314	5.8751	3.1432
	2.6418	4.0196	1.2775

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	3.4650	4.6292	3.0553
	2.9643	2.6366	3.5881
8/4	3.8806	4.3135	3.4065
	3.3191	2.7647	2.4040
16/8	7.0009	6.7208	4.5376
	7.0643	5.2801	4.1029

SEGMENT 2 VARIABLE 39 S/PITCH

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.7447	0.7484	0.7474
	0.0057	0.0056	0.0062
8/4	0.7459	0.7446	0.7449
	0.0070	0.0081	0.0108
16/8	0.7524	0.7523	0.7529
	0.0095	0.0138	0.0102

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.7449	0.7480	0.7460
	0.0070	0.0083	0.0071
8/4	0.7470	0.7463	0.7490
	0.0084	0.0089	0.0093
16/8	0.7587	0.7542	0.7557
	0.0258	0.0129	0.0159

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SEGMENT 2 VARIABLE 40 S/ROLL

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	1.1405	1.1390	1.1364
	0.0071	0.0067	0.0127
8/4	1.1329	1.1340	1.1266
	0.0075	0.0129	0.0184
16/8	1.1181	1.1261	1.1258
	0.0211	0.0180	0.0142

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	1.1328	1.1391	1.1312
	0.0139	0.0129	0.0162
8/4	1.1260	1.1284	1.1275
	0.0195	0.0156	0.0138
16/8	1.1177	1.1143	1.1180
	0.0278	0.0343	0.0313

SEGMENT 2 VARIABLE 41 S/YAW

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.7315	0.7299	0.7215
	0.0094	0.0096	0.0346
8/4	0.7352	0.7318	0.7273
	0.0136	0.0123	0.0247
16/8	0.7279	0.7293	0.7294
	0.0261	0.0235	0.0158

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.7157	0.7244	0.7160
	0.0262	0.0183	0.0315
8/4	0.7236	0.7233	0.7226
	0.0233	0.0190	0.0155
16/8	0.7208	0.7150	0.7204
	0.0272	0.0353	0.0293

SEGMENT 2 VARIABLE 42 POWSET

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.3240	0.3269	0.3412
	0.0166	0.0246	0.0477
8/4	0.3262	0.3286	0.3456
	0.0279	0.0326	0.0397
16/8	0.3432	0.3288	0.3315
	0.0447	0.0432	0.0369

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.3472	0.3248	0.3536
	0.0425	0.0407	0.0451
8/4	0.3414	0.3348	0.3451
	0.0433	0.0407	0.0352
16/8	0.3431	0.3499	0.3465
	0.0659	0.0628	0.0554

SEGMENT 2 VARIABLE 43 ALTERR

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	13.0733	14.2832	11.7291
	7.4685	7.0827	7.2820
8/4	13.4541	18.5397	13.1227
	6.5006	15.0099	7.2664
16/8	18.7441	27.2251	30.7020
	11.0267	21.5334	39.1886

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	13.2300	14.7769	12.0162
	8.1016	8.3138	12.3751
8/4	16.1279	23.0122	13.0573
	8.5886	25.3297	7.8415
16/8	35.7752	28.6181	22.0450
	50.0071	35.0708	15.6173

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SEGMENT 2 VARIABLE 44 CXERR

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	14.3221	20.9630	75.0182
	7.2121	10.1177	288.8928
8/4	24.8614	34.2991	27.0529
	11.7451	52.7739	16.7128
16/8	36.2432	56.5920	45.4001
	22.7530	56.3472	55.1106

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	17.7647	20.1812	21.4021
	13.2655	9.6858	21.7808
8/4	34.2733	30.1847	103.5706
	52.3599	11.2203	403.6746
16/8	56.7687	73.3961	166.4762
	89.2564	112.8522	408.4861

SEGMENT 2 VARIABLE 45 SACCLM

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	1.5545	1.2064	1.6993
	0.4475	0.6555	0.7728
8/4	1.5249	1.2338	1.6166
	0.4543	0.5474	0.5457
16/8	1.6191	1.2749	1.6737
	0.8199	0.9257	0.7816

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	1.5596	1.4062	1.7044
	0.6136	0.7359	0.6973
8/4	1.6429	1.4351	1.6451
	0.6205	0.7207	0.5210
16/8	1.6790	1.5270	1.7587
	0.5393	0.5448	0.5269

SEGMENT 2 VARIABLE 46 SACCLS

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	1.5267	1.5943	1.5174
	0.7636	1.0628	0.6596
8/4	1.4651	1.5792	1.5291
	0.7475	0.8805	0.7234
16/8	1.4987	1.3838	1.4085
	0.7046	1.0592	0.7898

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	1.5693	1.5748	1.5882
	0.8584	0.7845	0.6742
8/4	1.5822	1.5654	1.5962
	0.5936	0.7956	0.6326
16/8	1.7077	1.6544	1.6360
	0.7564	0.7280	0.6278

SEGMENT 2 VARIABLE 47 DWELLM

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.5025	1.0704	0.5240
	0.1897	0.7012	0.3819
8/4	0.5268	0.9702	0.4723
	0.2139	0.5903	0.1250
16/8	0.5767	1.1925	0.5481
	0.4787	0.9213	0.3076

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.4040	0.5107	0.3442
	0.1838	0.2896	0.1357
8/4	0.3694	0.4770	0.2970
	0.1901	0.2860	0.0718
16/8	0.2861	0.3573	0.2827
	0.0671	0.1946	0.0868

SEGMENT 2 VARIABLE 48 DWELLS

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.4454	0.9849	0.5487
	0.2280	0.7454	0.7336
8/4	0.4683	0.8762	0.4328
	0.2632	0.6097	0.1412
16/8	0.5905	1.2512	0.5719
	0.8083	1.2201	0.5828

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.3283	0.5159	0.2928
	0.1718	0.4580	0.2460
8/4	0.3094	0.4562	0.2269
	0.2573	0.4100	0.0782
16/8	0.2078	0.3174	0.2149
	0.0720	0.2978	0.0933

SEGMENT 2 VARIABLE 49 FIXRATE

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	2.2106	1.3079	2.1837
	0.6718	0.6678	0.5656
8/4	2.1526	1.4343	2.1905
	0.6872	0.7175	0.4794
16/8	2.1806	1.4264	2.0921
	0.7272	0.8804	0.6680

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	2.9336	2.5324	3.1977
	0.7319	0.8999	0.7894
8/4	3.1305	2.6952	3.3237
	0.8662	0.9894	0.5656
16/8	3.4404	3.0913	3.3796
	0.5777	0.6948	0.5385

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SEGMENT 2 VARIABLE 50 BLINKR

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.1109	0.1204	0.0866
	0.0636	0.0929	0.0741
8/4	0.1538	0.1424	0.1576
	0.1220	0.1236	0.3890
16/8	0.1355	0.1297	0.0789
	0.1284	0.1159	0.0704

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.4467	0.4779	0.3683
	0.9441	0.9466	0.5538
8/4	0.3282	0.3687	0.2678
	0.3824	0.3303	0.1830
16/8	0.4727	0.5213	0.4291
	0.3717	0.6711	0.3226

SEGMENT 2 VARIABLE 51 PUPILD

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	5.5670	5.9179	5.4489
	1.3259	1.4235	1.3622
8/4	5.6519	5.8203	5.5330
	1.1693	1.2013	1.3521
16/8	5.8141	5.9408	5.7553
	1.1866	1.2577	1.3039

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	5.3614	5.4141	5.3167
	1.3848	1.3931	1.4064
8/4	5.3500	5.4438	5.3771
	1.2829	1.1777	1.2868
16/8	5.5396	5.4915	5.4978
	1.1937	1.1286	1.3655

SEGMENT 3 VARIABLE 1 EMGARM

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	15.9481	16.9106	17.1081
	7.7018	8.0760	7.6929
8/4	16.8917	16.9908	17.3401
	7.6368	7.4113	8.4646
16/8	17.2429	17.4624	17.2667
	7.5526	7.5654	6.9299

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	17.7358	20.2661	19.0329
	8.2194	9.6711	8.4105
8/4	18.8398	21.0685	18.5770
	8.0450	9.4373	6.5660
16/8	20.9799	22.3548	21.7892
	8.5170	9.6977	9.5622

SEGMENT 3 VARIABLE 2 EMGARS

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	10.4843	11.4463	11.6918
	5.3613	5.5374	5.1032
8/4	11.4230	11.4203	11.7684
	5.3270	5.0013	6.1648
16/8	11.5450	11.9420	11.9547
	5.6072	5.4298	5.0550

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	12.4869	14.1368	12.6167
	6.5832	6.5856	5.7519
8/4	12.6703	14.3739	13.1207
	6.0942	7.1010	4.9703
16/8	14.4244	15.9811	15.4736
	6.3809	6.8055	7.4093

SEGMENT 3 VARIABLE 4 EMGALR

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	13.0535	14.4074	12.4387
	5.4193	6.8125	5.1264
8/4	13.7932	14.8438	12.6317
	6.1706	8.4443	6.6048
16/8	14.0967	16.2221	13.2649
	6.7439	8.1514	6.1193

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	14.1794	15.5250	12.3295
	6.9971	8.5131	6.5528
8/4	15.6454	16.7013	13.9671
	9.8866	10.0296	6.9635
16/8	16.7637	16.7574	15.0136
	9.6243	9.8864	8.0072

SEGMENT 3 VARIABLE 5 EMGALS

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	9.1004	10.1404	8.7723
	4.1839	5.1662	3.8146
8/4	9.5823	10.5496	8.9637
	4.7488	6.4580	4.7190
16/8	9.8554	11.9789	9.3119
	5.1591	6.5738	4.4600

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	10.1497	11.3605	8.6344
	5.1663	6.3106	4.7237
8/4	11.1381	11.8720	10.0579
	7.3686	7.4272	4.9316
16/8	11.7694	12.0622	10.6004
	6.7318	7.4383	5.4688

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SEGMENT 3 VARIABLE 7 RESAMP

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	143.7879	140.9213	142.6782
	52.6647	48.6154	53.6968
8/4	139.2854	141.2215	138.4792
	48.9073	50.8090	49.1372
16/8	141.4294	140.3400	141.4009
	49.4428	42.8729	49.8026

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	143.7482	139.1166	144.0585
	55.4880	50.6675	47.5810
8/4	139.3396	137.2919	143.1186
	48.3701	45.7734	47.0364
16/8	136.2108	137.3044	145.1432
	43.0945	45.8434	46.6244

SEGMENT 3 VARIABLE 8 RESAMS

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	21.3087	21.8907	21.3900
	11.2110	14.4962	9.2214
8/4	24.7726	25.6952	19.1380
	19.0992	18.0097	7.5229
16/8	26.4591	21.6257	24.9631
	19.5416	8.1355	16.5421

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	26.6747	21.3049	21.9574
	20.1011	9.3877	9.8829
8/4	23.8757	21.3924	23.3661
	11.8503	9.5221	11.6649
16/8	25.4441	26.5152	27.1935
	10.5868	10.7517	20.6866

SEGMENT 3 VARIABLE 9 RESPDM

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	2.7195	2.6021	2.6126
	0.3752	0.3411	0.3090
8/4	2.6729	2.5808	2.5839
	0.3941	0.3724	0.3117
16/8	2.5718	2.5268	2.5806
	0.2964	0.3263	0.3841

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	2.5358	2.5155	2.6007
	0.3197	0.4982	0.4786
8/4	2.7735	2.6458	2.4310
	1.6640	0.7888	0.3417
16/8	2.7004	2.4197	2.4466
	2.0134	0.4325	0.6788

SEGMENT 3 VARIABLE 10 RESPDS

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.2484	0.2183	0.2251
	0.1802	0.1028	0.0964
8/4	0.2798	0.3075	0.2563
	0.1863	0.2974	0.1979
16/8	0.2324	0.2085	0.2671
	0.1128	0.0868	0.2029

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.3079	0.3631	0.3217
	0.2420	0.5208	0.4062
8/4	0.3582	0.4322	0.2992
	0.6592	0.7240	0.2238
16/8	0.2807	0.3452	0.3028
	0.1970	0.3745	0.2779

SEGMENT 3 VARIABLE 13 ECGRAM

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	245.6253	246.6401	244.4693
	95.3290	95.1115	94.1354
8/4	242.9621	246.9642	243.8627
	92.8967	95.1936	93.6151
16/8	245.8581	247.1077	242.3693
	93.5370	94.8725	91.9543

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	246.8905	251.1355	249.8946
	93.6033	94.6931	94.6884
8/4	246.5082	246.8025	247.2586
	94.5288	94.1272	94.6764
16/8	243.0157	242.7926	247.4874
	92.2745	91.9962	95.1550

SEGMENT 3 VARIABLE 14 ECGRAS

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	18.1702	17.8398	23.8857
	19.5382	18.2749	24.3012
8/4	22.9150	18.9402	23.3336
	23.4913	20.0924	25.2151
16/8	18.3400	17.0343	22.8410
	20.8597	19.0989	22.6942

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	23.4919	22.9261	19.4302
	24.5790	21.5595	19.0195
8/4	22.1806	21.0375	27.0470
	22.6285	21.9810	22.4825
16/8	24.2552	27.0048	22.2375
	23.7448	24.3511	20.6792

SEGMENT 3 VARIABLE 15 ECGRDM

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.7212	0.7091	0.7144
	0.0870	0.0734	0.0844
8/4	0.7093	0.6961	0.6963
	0.0624	0.0752	0.0878
16/8	0.7131	0.6865	0.7005
	0.0780	0.0722	0.0749

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.7104	0.7153	0.7047
	0.0823	0.0728	0.0954
8/4	0.7023	0.6963	0.6890
	0.0826	0.0757	0.0849
16/8	0.6846	0.6727	0.6981
	0.0797	0.0809	0.0845

SEGMENT 3 VARIABLE 16 ECGRDS

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.0834	0.0930	0.0856
	0.0497	0.0538	0.0495
8/4	0.0882	0.0841	0.0834
	0.0560	0.0428	0.0415
16/8	0.0888	0.0817	0.0918
	0.0480	0.0493	0.0515

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.0922	0.0995	0.0810
	0.0467	0.0499	0.0446
8/4	0.1033	0.1118	0.1135
	0.0564	0.0653	0.0513
16/8	0.1066	0.1021	0.1180
	0.0541	0.0693	0.0619

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SEGMENT 3 VARIABLE 17 ECGP/R

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.0057	0.0043	0.0060
	0.0294	0.0275	0.0282
8/4	0.0069	0.0041	0.0105
	0.0288	0.0289	0.0303
16/8	0.0041	0.0071	0.0035
	0.0285	0.0267	0.0292

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.0114	0.0111	0.0110
	0.0311	0.0329	0.0318
8/4	0.0133	0.0090	0.0147
	0.0334	0.0306	0.0312
16/8	0.0112	0.0154	0.0117
	0.0331	0.0333	0.0301

SEGMENT 3 VARIABLE 18 ECGQ/R

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	-0.1450	-0.1491	-0.1490
	0.0692	0.0736	0.0705
8/4	-0.1406	-0.1489	-0.1431
	0.0648	0.0681	0.0645
16/8	-0.1486	-0.1478	-0.1451
	0.0726	0.0712	0.0688

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	-0.1464	-0.1470	-0.1531
	0.0622	0.0638	0.0685
8/4	-0.1487	-0.1540	-0.1447
	0.0644	0.0691	0.0538
16/8	-0.1534	-0.1575	-0.1505
	0.0636	0.0676	0.0611

SEGMENT 3 VARIABLE 20 ECGS/R

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	-0.1707	-0.1715	-0.1717
	0.0630	0.0632	0.0635
8/4	-0.1741	-0.1712	-0.1725
	0.0611	0.0599	0.0561
16/8	-0.1695	-0.1740	-0.1682
	0.0575	0.0595	0.0561

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	-0.1767	-0.1805	-0.1743
	0.0654	0.0664	0.0674
8/4	-0.1806	-0.1854	-0.1823
	0.0636	0.0678	0.0622
16/8	-0.1901	-0.1880	-0.1895
	0.0678	0.0660	0.0627

SEGMENT 3 VARIABLE 21 ECGT/R

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.1511	0.1547	0.1590
	0.0657	0.0699	0.0723
8/4	0.1595	0.1574	0.1529
	0.0655	0.0638	0.0630
16/8	0.1554	0.1594	0.1597
	0.0636	0.0714	0.0722

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.1458	0.1416	0.1517
	0.0615	0.0565	0.0676
8/4	0.1502	0.1548	0.1480
	0.0658	0.0665	0.0632
16/8	0.1579	0.1565	0.1553
	0.0690	0.0659	0.0640

SEGMENT 3 VARIABLE 22 ECGPIN

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.0232	0.0470	0.0465
	0.0531	0.0701	0.0763
8/4	0.0484	0.0440	0.0512
	0.0698	0.0666	0.0715
16/8	0.0586	0.0489	0.0493
	0.0764	0.0737	0.0715

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.0469	0.0597	0.0560
	0.0651	0.0740	0.0721
8/4	0.0629	0.0745	0.0759
	0.0762	0.0801	0.0766
16/8	0.0562	0.0602	0.0634
	0.0683	0.0675	0.0709

SEGMENT 3 VARIABLE 23 ECGQIN

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.1931	0.1793	0.1924
	0.0946	0.0960	0.0953
8/4	0.1893	0.1926	0.1801
	0.0939	0.0952	0.0920
16/8	0.1859	0.1796	0.1934
	0.0959	0.0958	0.0947

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.1823	0.1862	0.1826
	0.0951	0.0928	0.0953
8/4	0.1778	0.1785	0.1672
	0.0976	0.0972	0.0954
16/8	0.1834	0.1796	0.1890
	0.0959	0.0979	0.0951

SEGMENT 3 VARIABLE 24 ECGRIN

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.0394	0.0394	0.0395
	0.0056	0.0057	0.0062
8/4	0.0391	0.0396	0.0394
	0.0055	0.0062	0.0057
16/8	0.0390	0.0391	0.0395
	0.0052	0.0057	0.0060

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.0389	0.0388	0.0386
	0.0061	0.0061	0.0055
8/4	0.0383	0.0381	0.0383
	0.0055	0.0056	0.0058
16/8	0.0378	0.0379	0.0380
	0.0058	0.0062	0.0061

SEGMENT 3 VARIABLE 25 ECGSIN

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.1457	0.1435	0.1432
	0.0303	0.0284	0.0272
8/4	0.1433	0.1407	0.1430
	0.0237	0.0243	0.0244
16/8	0.1417	0.1406	0.1425
	0.0246	0.0223	0.0246

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.1447	0.1415	0.1403
	0.0285	0.0279	0.0272
8/4	0.1391	0.1403	0.1416
	0.0234	0.0247	0.0208
16/8	0.1395	0.1376	0.1401
	0.0231	0.0214	0.0217

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SEGMENT 3 VARIABLE 26 ECGTIN

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.1288	0.1278	0.1311
	0.0292	0.0298	0.0343
8/4	0.1312	0.1291	0.1289
	0.0308	0.0310	0.0283
16/8	0.1301	0.1276	0.1311
	0.0257	0.0268	0.0314

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.1255	0.1275	0.1275
	0.0350	0.0356	0.0319
8/4	0.1265	0.1230	0.1198
	0.0337	0.0344	0.0319
16/8	0.1231	0.1222	0.1224
	0.0308	0.0319	0.0326

SEGMENT 3 VARIABLE 31 PITCH

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.1040	0.1656	0.1000
	0.0681	0.0776	0.0462
8/4	0.1315	0.1701	0.0983
	0.0707	0.0609	0.0502
16/8	0.1555	0.1682	0.1189
	0.0710	0.0653	0.0635

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.1143	0.1545	0.0824
	0.0622	0.0656	0.0460
8/4	0.1224	0.1564	0.1045
	0.0597	0.0789	0.0625
16/8	0.1431	0.1673	0.1119
	0.0842	0.0534	0.0670

SEGMENT 3 VARIABLE 32 ROLL

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.1161	0.1447	0.1648
	0.0479	0.0702	0.0858
8/4	0.1501	0.1771	0.1739
	0.0652	0.0725	0.0996
16/8	0.1686	0.1859	0.2212
	0.0628	0.0770	0.1213

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.1024	0.1500	0.1327
	0.0545	0.0907	0.1166
8/4	0.1284	0.1758	0.1778
	0.0613	0.1051	0.1427
16/8	0.2105	0.2242	0.2188
	0.1074	0.1015	0.1339

SEGMENT 3 VARIABLE 33 POWER

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.0941	0.1524	0.1272
	0.0607	0.1177	0.1029
8/4	0.1175	0.1977	0.1047
	0.0757	0.1436	0.0612
16/8	0.1730	0.2342	0.1782
	0.0910	0.1515	0.0875

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.1206	0.1872	0.0758
	0.0820	0.1422	0.0446
8/4	0.1135	0.1918	0.1225
	0.0520	0.1433	0.0738
16/8	0.2042	0.2451	0.1775
	0.0872	0.1343	0.0987

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SEGMENT 3 VARIABLE 34 HEADING

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.1512	0.2112	0.4453
	0.0672	0.1615	0.2271
8/4	0.1541	0.2177	0.4161
	0.0694	0.1582	0.2261
16/8	0.2074	0.2405	0.4542
	0.1374	0.1612	0.2010

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.1472	0.1768	0.3904
	0.1114	0.1150	0.1855
8/4	0.1754	0.2022	0.3649
	0.1402	0.1768	0.1752
16/8	0.2384	0.2889	0.3828
	0.1315	0.1804	0.1742

SEGMENT 3 VARIABLE 35 ROLLAC

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	2.6551	2.9852	3.9353
	0.6216	1.3062	1.6007
8/4	2.9318	3.1999	3.9842
	0.7444	0.9116	1.2842
16/8	3.8899	3.8612	5.0199
	0.8842	1.0933	2.1112

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	3.1525	3.7148	4.0610
	1.2563	1.6692	1.4399
8/4	3.1916	3.8464	4.7295
	1.1260	1.4545	2.2964
16/8	4.8819	5.2304	5.6158
	1.3308	1.9874	1.9146

SEGMENT 3 VARIABLE 36 PITCHAC

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	1.1177	1.3167	1.6491
	0.4228	0.7512	0.8561
8/4	1.1627	1.5132	1.6260
	0.3605	0.7047	0.9057
16/8	1.3964	1.6665	2.0521
	0.5455	0.9371	0.9894

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	1.4378	2.0458	1.8592
	0.9560	1.3225	1.0006
8/4	1.4411	2.0622	2.1626
	0.7587	1.2989	1.3405
16/8	1.8664	2.6005	2.4681
	1.2050	1.7139	1.8601

SEGMENT 3 VARIABLE 37 YAWACC

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	2.5976	3.1577	4.1020
	1.0703	2.2350	3.5464
8/4	3.0483	3.4521	3.8505
	1.6043	1.4856	2.5438
16/8	3.7786	3.6650	5.3064
	1.8577	2.1659	5.4050

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	1.8046	2.2947	2.4337
	0.6420	1.0650	1.5860
8/4	2.2545	2.8692	3.1705
	0.9172	1.8849	2.2113
16/8	3.1384	3.6609	3.7080
	1.3860	1.6140	2.4073

SEGMENT 3 VARIABLE 38 SPEEDER

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	3.0386	6.1492	4.5334
	3.1602	4.9876	5.5818
8/4	4.0927	6.7405	3.4152
	5.1670	4.3011	3.7873
16/8	6.2433	6.3615	4.3017
	5.9759	4.8585	3.2113

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	4.6799	7.4138	2.3265
	5.1202	6.7858	1.7614
8/4	3.7915	5.8898	3.5022
	3.1705	5.1973	3.2427
16/8	7.7983	8.4653	5.7753
	8.5199	6.7078	7.0241

SEGMENT 3 VARIABLE 39 S/PITCH

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.6726	0.6825	0.6787
	0.0174	0.0223	0.0184
8/4	0.6677	0.6771	0.6711
	0.0192	0.0199	0.0160
16/8	0.6719	0.6737	0.6741
	0.0198	0.0231	0.0184

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.6755	0.6856	0.6779
	0.0156	0.0237	0.0140
8/4	0.6718	0.6761	0.6738
	0.0148	0.0174	0.0174
16/8	0.6859	0.6876	0.6755
	0.0212	0.0234	0.0229

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SEGMENT 3 VARIABLE 40 S/ROLL

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	1.0289	1.0322	1.0335
	0.0059	0.0085	0.0284
8/4	0.9971	0.9997	1.0012
	0.0111	0.0135	0.0175
16/8	0.9646	0.9716	0.9732
	0.0181	0.0260	0.0236

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	1.0283	1.0336	1.0253
	0.0057	0.0099	0.0072
8/4	0.9968	0.9976	1.0018
	0.0097	0.0136	0.0214
16/8	0.9758	0.9771	0.9758
	0.0307	0.0259	0.0309

SEGMENT 3 VARIABLE 41 S/YAW

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.5663	0.5681	0.5544
	0.0077	0.0104	0.0265
8/4	0.5919	0.5908	0.5831
	0.0165	0.0162	0.0168
16/8	0.6104	0.6129	0.5990
	0.0190	0.0196	0.0226

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.5588	0.5693	0.5558
	0.0133	0.0153	0.0124
8/4	0.5854	0.5865	0.5752
	0.0142	0.0186	0.0202
16/8	0.6105	0.6040	0.5972
	0.0208	0.0236	0.0246

SEGMENT 3 VARIABLE 42 POWSET

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.4982	0.5091	0.5081
	0.0238	0.0283	0.0244
8/4	0.4982	0.5089	0.5106
	0.0250	0.0311	0.0263
16/8	0.5033	0.4993	0.5121
	0.0252	0.0260	0.0266

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.5084	0.5110	0.5115
	0.0280	0.0303	0.0217
8/4	0.5065	0.5123	0.5141
	0.0264	0.0301	0.0271
16/8	0.5166	0.5159	0.5132
	0.0212	0.0325	0.0335

SEGMENT 3 VARIABLE 43 ALTERR

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	4.8347	8.3821	6.5231
	3.2461	6.9502	6.5373
8/4	5.8182	11.7439	4.8003
	4.2876	11.2757	3.3813
16/8	9.4362	14.4307	9.3552
	9.5106	16.5954	6.0439

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	6.4553	10.5774	4.3041
	5.4788	10.5892	4.2319
8/4	6.1067	10.8182	6.2386
	3.2984	9.6424	4.9791
16/8	13.3388	17.0560	9.9251
	9.5174	19.4978	11.5736

SEGMENT 3 VARIABLE 44 CXERR

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	19.4286	24.0516	67.2487
	10.9292	14.7630	187.7090
8/4	27.9853	39.6808	34.2910
	16.4558	33.5546	35.6653
16/8	70.4190	110.9762	107.7403
	60.1378	228.6744	140.0741

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	18.7158	28.9320	31.3792
	13.2651	24.5223	58.5156
8/4	29.3994	48.3053	131.9552
	19.0170	61.1404	431.1321
16/8	138.4967	175.7828	348.2080
	145.2935	250.9131	934.9590

SEGMENT 3 VARIABLE 45 SACCLM

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	1.3897	0.9549	1.4659
	0.4253	0.5950	0.8412
8/4	1.3366	1.0193	1.4168
	0.5138	0.6516	0.4341
16/8	1.3652	1.0916	1.5243
	0.7638	1.1072	0.7072

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	1.4522	1.2732	1.5108
	0.6095	0.6677	0.5416
8/4	1.4329	1.3661	1.4593
	0.6140	0.9387	0.4221
16/8	1.3271	1.1687	1.5657
	0.3702	0.3871	0.7290

SEGMENT 3 VARIABLE 46 SACCLS

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	1.3122	0.9984	1.1068
	0.7231	0.9582	0.7197
8/4	1.1970	1.1481	1.2048
	0.8326	1.0161	0.7283
16/8	1.1267	1.0575	1.1638
	0.8285	1.0269	0.7337

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	1.4267	1.3447	1.3564
	0.7921	0.7893	0.6489
8/4	1.3876	1.4020	1.3301
	0.7301	0.8859	0.6065
16/8	1.2220	1.2102	1.3907
	0.6001	0.5883	0.8206

SEGMENT 3 VARIABLE 47 DWELLM

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.5997	1.2693	0.6454
	0.2011	0.8633	0.6147
8/4	0.6219	1.2959	0.5434
	0.3006	0.8040	0.1734
16/8	0.6374	1.2842	0.5846
	0.3787	0.8737	0.3248

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.4434	0.5462	0.4114
	0.1935	0.3163	0.2504
8/4	0.4644	0.5508	0.3571
	0.3388	0.3275	0.1085
16/8	0.3480	0.4326	0.3940
	0.1148	0.2518	0.5590

SEGMENT 3 VARIABLE 48 DWELLS

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.5613	1.1094	0.6810
	0.2715	0.8653	0.8568
8/4	0.5955	1.2124	0.5299
	0.4026	0.9534	0.2232
16/8	0.5971	1.2535	0.5794
	0.4941	1.0871	0.5203

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.3694	0.5386	0.3939
	0.2327	0.4750	0.4375
8/4	0.4386	0.5467	0.3015
	0.5207	0.5034	0.1038
16/8	0.2859	0.4008	0.3026
	0.1526	0.3436	0.4527

SEGMENT 3 VARIABLE 49 FIXRATE

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	1.8211	1.1510	1.8449
	0.5851	0.6455	0.7279
8/4	1.9009	1.1046	1.9444
	0.7236	0.5985	0.4750
16/8	1.8859	1.1646	1.8851
	0.7037	0.6808	0.5347

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	2.7144	2.4262	2.8332
	0.7695	0.9043	0.8204
8/4	2.7808	2.2692	2.9704
	0.9726	0.8628	0.7035
16/8	3.0549	2.7197	3.2826
	0.7224	0.7496	0.7622

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SEGMENT 3 VARIABLE 50 BLINKR

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	0.0907	0.1613	0.0968
	0.0702	0.2252	0.0853
8/4	0.1373	0.1165	0.0985
	0.0962	0.1050	0.0926
16/8	0.1006	0.1276	0.0807
	0.1160	0.1349	0.0590

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	0.3666	0.4017	0.2604
	0.4471	0.4582	0.2935
8/4	0.2846	0.5069	0.3057
	0.2583	0.7330	0.4718
16/8	0.2858	0.4939	0.3035
	0.2321	0.6914	0.2772

SEGMENT 3 VARIABLE 51 PUPILD

MOTION = NO

	GRAPH I	GRAPH II	F-DIR
0/0	5.6832	6.0248	5.6626
	1.3648	1.4045	1.5909
8/4	5.6767	6.0425	5.7042
	1.1186	1.1617	1.2478
16/8	5.9038	6.0540	5.9430
	1.2011	1.2894	1.4844

MOTION = YES

	GRAPH I	GRAPH II	F-DIR
0/0	5.3644	5.3987	5.4381
	1.3268	1.3406	1.5621
8/4	5.5143	5.4940	5.4198
	1.2908	1.2421	1.4104
16/8	5.6506	5.5419	5.5207
	1.1863	1.2400	1.4249

APPENDIX B

CORRELATION MATRICES

CORRELATION MATRIX APPROACH SEGMENT

1 EMGARM

1.000 0.943 0.483 0.445 -0.225 -0.149 -0.171 0.128 0.120 -0.058
-0.008 -0.181 -0.242 -0.121 -0.236 0.141 -0.302 0.368 -0.283 -0.147
0.014 -0.181 0.363 0.155 -0.220 0.045 -0.109 -0.165 -0.011 0.040
0.252 -0.081 -0.045 0.041 0.141 -0.039 0.147 0.145 -0.055 -0.052
0.125 0.104 -0.059 -0.025 -0.061 -0.027

2 EMGARS

0.943 1.000 0.500 0.408 -0.154 -0.072 -0.181 0.145 0.200 -0.002
0.011 -0.148 -0.511 -0.155 -0.283 0.147 -0.509 0.042 -0.248 -0.204
-0.041 -0.150 0.555 0.120 0.252 0.058 -0.124 -0.171 -0.021 0.022
0.250 -0.087 -0.058 0.027 0.158 0.051 0.155 0.209 -0.012 -0.055
0.100 0.058 -0.080 -0.055 -0.020 -0.038

3 EMGALM

0.483 0.500 1.000 0.788 -0.248 -0.182 -0.025 -0.051 -0.184 -0.130
0.147 -0.249 0.115 0.408 -0.590 -0.158 -0.080 0.007 -0.250 0.291
0.073 -0.218 0.285 0.071 -0.083 -0.058 0.029 -0.055 0.070 0.145
0.159 -0.108 -0.049 0.182 -0.090 -0.025 -0.082 -0.048 -0.087 -0.058
0.189 0.079 -0.594 0.082 0.155 0.058

4 EMGALS

0.445 0.408 0.788 1.000 -0.220 -0.155 -0.011 -0.049 -0.179 -0.117
0.217 -0.285 0.105 0.595 -0.295 -0.104 -0.078 0.052 -0.190 0.285
0.158 -0.291 0.295 0.012 -0.115 -0.093 0.019 -0.085 0.060 0.120
0.121 -0.095 -0.080 0.151 -0.154 -0.055 -0.094 -0.082 -0.089 -0.085
0.165 0.048 -0.550 0.024 0.140 0.058

5 RESAMP

-0.225 -0.154 -0.248 -0.220 1.000 0.588 -0.178 -0.115 0.600 0.445
-0.187 0.451 0.595 0.885 0.520 0.519 -0.082 0.228 0.208 -0.540
-0.412 0.521 -0.258 -0.062 0.053 -0.078 0.104 0.287 -0.027 -0.104
-0.198 0.115 0.287 0.199 0.021 -0.005 0.088 0.079 0.084 0.122
-0.152 -0.079 0.548 0.025 -0.042 0.056

6 RESAMS

-0.189 -0.072 -0.182 -0.155 0.588 1.000 0.098 0.280 0.474 0.480
-0.015 0.512 0.424 0.451 0.571 0.458 -0.240 0.373 0.575 -0.405
-0.178 0.292 0.227 0.124 0.115 0.043 0.102 0.093 0.083 -0.067
-0.082 0.021 0.139 0.071 0.110 0.017 -0.021 0.057 0.045 0.081
-0.088 -0.059 0.591 0.085 -0.021 0.085

7 RESPDM

-0.171 -0.181 -0.025 -0.011 -0.178 0.098 1.000 0.424 -0.218 0.007
0.579 -0.224 -0.020 0.228 0.045 -0.072 -0.271 0.582 0.555 0.407
0.170 -0.054 -0.159 -0.525 -0.525 -0.123 -0.194 -0.549 -0.089 -0.191
-0.088 0.181 0.058 -0.059 -0.518 -0.058 -0.275 -0.548 0.128 0.137
-0.145 -0.121 -0.549 -0.114 -0.175 -0.105

8 RESPDS

0.128 0.143 -0.051 -0.049 -0.115 0.280 0.424 1.000 0.076 0.072
-0.048 0.063 -0.114 -0.126 0.050 0.124 -0.154 0.144 0.065 -0.042
-0.000 -0.051 -0.052 0.002 -0.006 -0.055 -0.058 -0.127 -0.033 -0.021
0.050 -0.037 -0.052 0.025 0.002 0.122 0.149 0.105 -0.048 -0.043
0.113 0.145 -0.011 -0.015 0.132 -0.021

9 ECGRAM

0.120 0.200 -0.184 -0.179 0.000 0.478 -0.210 0.076 1.000 0.442
0.131 0.537 -0.756 -0.541 0.124 0.547 -0.413 0.054 -0.024 -0.071
-0.542 0.516 -0.119 -0.017 0.098 -0.060 -0.095 0.011 -0.062 -0.187
-0.014 0.045 0.247 -0.171 0.052 -0.004 0.533 0.384 0.045 0.077
-0.084 -0.064 0.557 -0.001 -0.080 -0.059

10 ECGRAS

-0.058 -0.002 -0.150 -0.117 0.445 0.460 0.007 0.072 0.442 1.000
0.044 0.520 -0.581 -0.541 0.512 0.486 -0.273 0.574 0.247 -0.573
-0.160 0.316 -0.148 -0.078 -0.125 -0.101 0.002 0.016 0.042 -0.105
-0.041 0.051 0.146 -0.115 -0.124 -0.059 -0.042 -0.050 0.060 0.063
-0.109 -0.044 0.382 0.053 -0.081 0.021

11 ECGRDM

-0.008 0.011 0.197 0.217 -0.187 -0.015 0.579 -0.048 0.141 0.044
1.000 -0.255 -0.277 0.243 -0.250 0.126 -0.434 0.553 -0.055 0.364
0.173 -0.245 -0.020 -0.247 -0.392 -0.168 -0.214 -0.304 -0.118 -0.144
0.104 0.065 0.051 -0.024 -0.521 -0.151 -0.077 -0.084 -0.010 0.004
-0.015 -0.126 -0.343 -0.149 -0.041 -0.150

12 ECGRDS

-0.181 -0.144 -0.249 -0.245 0.451 0.512 -0.224 0.063 0.547 0.520
-0.255 1.000 -0.141 -0.328 0.282 0.255 0.174 -0.005 0.158 -0.450
-0.288 0.502 -0.185 0.075 0.101 0.052 0.182 0.296 0.028 0.078
-0.211 -0.006 0.094 -0.059 0.120 0.018 0.210 0.204 0.002 0.014
-0.013 0.064 0.471 0.041 0.018 0.048

13 ECGP/R

-0.242 -0.511 0.118 0.105 -0.343 -0.424 -0.020 -0.118 -0.754 -0.541
-0.277 -0.141 1.000 0.558 -0.245 -0.775 0.067 -0.817 -0.203 0.559
0.058 -0.254 0.037 0.154 -0.026 0.088 0.242 0.261 0.042 0.284
-0.082 -0.105 -0.248 0.182 0.022 0.072 -0.207 -0.215 -0.069 -0.085
0.117 0.143 -0.438 0.072 0.115 0.083

14 ECGQ/R

-0.121 -0.156 0.000 0.545 -0.443 -0.451 0.260 -0.126 -0.541 -0.541
0.293 -0.528 0.534 1.000 -0.599 -0.648 0.283 -0.520 -0.241 0.743
-0.026 -0.347 0.067 0.028 -0.138 0.062 0.044 -0.021 -0.048 0.069
0.022 0.026 -0.184 0.047 -0.071 0.012 -0.135 -0.044 -0.103 -0.120
0.120 0.009 -0.124 -0.044 0.055 -0.008

15 ECGS/R

-0.236 -0.243 -0.390 -0.243 0.523 0.571 0.085 0.050 0.124 0.512
-0.250 0.262 -0.245 -0.599 1.000 0.508 -0.128 0.198 0.655 -0.551
0.537 0.210 -0.208 -0.184 -0.471 -0.120 -0.063 -0.028 0.087 -0.218
-0.088 0.058 0.306 -0.150 -0.077 -0.060 -0.148 -0.215 0.105 0.108
-0.154 -0.128 0.555 0.058 -0.090 0.028

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16 ECGT/R
0.141 0.197 -0.156 -0.104 0.319 0.434 -0.072 0.124 0.597 0.486
0.126 0.255 -0.775 -0.694 0.504 1.000 -0.500 0.742 0.278 -0.588
0.210 0.279 -0.017 -0.080 0.008 -0.130 -0.134 -0.168 0.081 -0.203
0.044 -0.008 0.302 -0.096 -0.048 -0.116 0.177 0.150 0.037 0.057
-0.055 -0.107 0.545 0.048 -0.026 0.026

17 ECGPIN
-0.302 -0.349 -0.060 -0.078 -0.062 -0.240 -0.271 -0.154 -0.413 -0.273
-0.434 0.174 0.667 0.285 -0.126 -0.500 1.000 -0.759 -0.211 0.198
-0.090 0.137 -0.065 0.205 0.114 0.151 0.362 0.411 0.132 0.226
-0.164 -0.084 -0.144 0.045 0.175 0.085 0.018 0.052 -0.082 -0.094
0.136 0.125 -0.043 0.169 0.135 0.172

18 ECGQIN
0.588 0.442 0.007 0.052 0.226 0.373 0.062 0.144 0.659 0.574
0.353 -0.005 -0.877 -0.520 0.198 0.742 -0.759 1.000 0.152 -0.455
0.052 0.073 0.025 -0.145 -0.049 -0.149 -0.267 -0.526 -0.041 -0.231
0.146 0.036 0.224 -0.090 -0.097 -0.063 0.158 0.147 0.055 0.070
-0.067 -0.105 0.298 -0.075 -0.061 -0.087

19 ECGRIN
-0.263 -0.246 -0.250 -0.190 0.206 0.375 0.355 0.065 -0.024 0.297
-0.055 0.138 -0.205 -0.291 0.653 0.278 -0.211 0.152 1.000 -0.149
0.056 -0.005 -0.257 -0.282 -0.265 -0.102 0.006 -0.039 0.025 -0.207
-0.144 0.162 0.212 -0.162 -0.240 -0.114 -0.369 -0.446 0.180 0.163
-0.264 -0.111 0.214 0.010 -0.147 -0.013

20 ECGSIN
-0.147 -0.209 0.241 0.285 -0.540 -0.405 0.407 -0.042 -0.671 -0.373
0.364 -0.450 0.559 0.744 -0.331 -0.588 0.198 -0.455 -0.149 1.000
0.262 -0.560 0.078 -0.065 -0.278 -0.020 -0.006 -0.135 -0.015 0.056
0.056 -0.006 -0.183 0.048 -0.213 -0.035 -0.299 -0.323 -0.036 -0.047
0.054 0.019 -0.722 -0.036 0.038 -0.013

21 ECGTIN
0.014 -0.041 0.073 0.154 -0.412 -0.176 0.170 -0.000 -0.342 -0.160
0.173 -0.288 0.058 -0.026 0.337 0.210 -0.090 0.052 0.056 0.262
1.000 -0.308 0.105 -0.113 -0.177 -0.131 -0.090 -0.278 0.156 -0.061
0.176 -0.123 0.022 0.107 -0.170 -0.120 -0.144 -0.244 -0.079 -0.085
0.114 -0.122 -0.150 0.102 0.134 0.091

22 OPINION
-0.181 -0.150 -0.278 -0.291 0.521 0.292 -0.454 -0.031 0.516 0.516
-0.295 0.502 -0.234 -0.197 0.210 0.279 0.137 0.073 -0.005 -0.580
-0.588 1.000 -0.174 0.220 0.140 0.025 0.197 0.442 -0.021 -0.015
-0.149 0.027 0.159 -0.124 0.176 0.047 0.278 0.325 -0.101 -0.089
0.062 0.018 0.593 0.026 0.067 0.031

23 PITCH
0.363 0.335 0.289 0.245 -0.238 -0.227 -0.139 -0.052 -0.119 -0.148
-0.020 -0.165 0.057 0.067 -0.208 -0.017 -0.063 0.028 -0.257 0.078
0.105 -0.174 1.000 0.357 0.475 0.274 -0.013 0.043 0.144 0.255
0.309 -0.190 -0.108 0.157 0.346 0.113 0.073 0.113 0.012 0.002
0.036 0.124 -0.078 0.061 0.022 0.057

24 ROLL

0.155	0.126	0.071	0.012	-0.020	-0.124	-0.525	0.002	-0.017	-0.078
-0.247	0.075	0.154	0.028	-0.107	-0.040	0.205	-0.143	-0.282	-0.085
-0.113	0.220	0.357	1.000	0.541	0.501	0.513	0.433	0.459	0.155
0.120	-0.167	-0.142	0.154	0.416	0.399	0.144	0.232	-0.050	-0.056
0.202	0.209	0.062	0.450	0.144	0.447				

25 POWER

0.226	0.232	-0.064	-0.119	0.035	-0.115	-0.583	-0.006	0.098	-0.125
-0.302	0.101	-0.026	-0.138	-0.071	0.008	0.114	-0.044	-0.285	-0.218
-0.177	0.140	0.475	0.541	1.000	0.451	0.205	0.183	0.281	0.068
0.253	-0.168	-0.077	0.078	0.842	0.274	0.353	0.381	-0.065	-0.074
0.115	0.151	0.226	0.285	0.104	0.283				

26 HEADING

0.043	0.034	-0.054	-0.043	-0.078	-0.043	-0.123	-0.055	-0.060	-0.101
-0.168	0.052	0.068	0.062	-0.120	-0.130	0.151	-0.149	-0.102	-0.020
-0.151	0.025	0.274	-.501	0.451	1.000	0.471	0.206	0.539	0.115
0.079	-0.040	-0.204	0.127	0.336	0.296	0.105	0.101	0.136	0.133
-0.116	0.017	0.026	0.549	-0.116	0.556				

27 ROLLAC

-0.104	-0.124	0.029	0.019	0.104	0.102	-0.194	-0.058	-0.045	0.002
-0.218	0.162	0.242	0.049	-0.023	-0.134	0.562	-0.267	0.008	-0.008
-0.040	0.197	-0.013	0.513	0.205	0.471	1.000	0.662	0.777	0.251
-0.083	-0.209	-0.182	0.242	0.135	0.163	0.087	0.054	-0.115	-0.124
0.261	0.227	0.055	0.813	0.297	0.809				

28 PITCHAC

-0.165	-0.171	-0.035	-0.045	0.287	0.093	-0.349	-0.127	0.011	0.010
-0.304	0.296	0.201	-0.021	-0.028	-0.168	0.411	-0.526	-0.034	-0.135
-0.278	0.442	0.043	0.434	0.183	0.206	0.862	1.000	0.273	0.514
-0.207	-0.069	-0.143	0.110	0.105	0.166	0.097	0.118	-0.051	-0.057
0.184	0.203	0.182	0.271	0.201	0.267				

29 YAWACC

-0.011	-0.021	0.070	0.060	-0.027	0.083	-0.089	-0.043	-0.062	0.042
-0.118	0.028	0.042	-0.048	0.067	0.081	0.132	-0.041	0.025	-0.015
0.156	-0.021	0.144	0.459	0.281	0.539	0.777	0.273	1.000	0.121
0.106	-0.270	-0.101	0.255	0.146	0.086	0.034	-0.013	-0.030	-0.040
0.136	0.135	0.063	0.970	0.167	0.967				

30 SPEEDER

0.040	0.022	0.145	0.120	-0.104	-0.047	-0.191	-0.021	-0.187	-0.108
-0.148	0.078	0.288	0.064	-0.218	-0.203	0.226	-0.231	-0.207	0.056
-0.061	-0.015	0.255	0.155	0.068	0.113	0.231	0.314	0.121	1.000
-0.252	-0.528	-0.643	0.592	0.104	0.055	0.041	0.074	-0.130	-0.145
0.260	0.237	-0.087	0.222	0.257	0.211				

31 S/PITCH

0.252	0.230	0.134	0.121	-0.148	-0.082	-0.004	0.030	-0.014	-0.091
0.104	-0.211	-0.082	0.022	-0.086	0.049	-0.164	0.148	-0.144	0.056
0.176	-0.149	0.309	0.120	0.253	0.074	-0.063	-0.207	0.108	-0.252
1.000	-0.482	-0.145	0.445	0.205	0.102	0.088	0.024	0.020	0.015
0.026	-0.000	-0.070	0.067	0.051	0.047				

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32 S/ROLL

-0.081 -0.007 -0.106 -0.098 0.118 0.021 0.141 -0.057 0.095 0.051
0.005 -0.006 -0.105 0.026 0.058 -0.008 -0.084 0.056 0.162 -0.006
-0.125 0.021 -0.190 -0.167 -0.168 -0.040 -0.209 -0.089 -0.270 -0.528
-0.482 1.000 0.648 -0.492 -0.251 -0.057 -0.121 -0.080 0.140 0.155
-0.215 -0.145 0.004 -0.521 -0.298 -0.317

33 S/YAW

-0.040 -0.056 -0.049 -0.060 0.287 0.159 0.058 -0.052 0.247 0.149
0.051 0.044 -0.248 -0.184 0.309 0.302 -0.148 0.224 0.212 -0.163
0.022 0.154 -0.106 -0.142 -0.071 -0.208 -0.182 -0.133 -0.101 -0.643
-0.145 0.648 1.000 -0.185 -0.144 -0.078 -0.066 -0.046 0.056 0.064
-0.146 -0.141 0.201 -0.258 -0.147 -0.224

34 POWSET

0.094 0.074 0.152 0.151 -0.199 -0.071 -0.084 0.025 -0.171 -0.115
-0.024 -0.059 0.182 0.047 -0.150 -0.096 0.045 -0.040 -0.102 0.088
0.107 -0.128 0.157 0.154 0.074 0.121 0.242 0.110 0.255 0.542
0.445 -0.492 -0.785 1.000 0.150 0.047 0.080 0.035 -0.088 -0.103
0.238 0.208 -0.124 0.351 0.252 0.542

35 ALTERR

0.141 0.135 -0.040 -0.134 0.027 -0.110 -0.518 0.002 0.062 -0.124
-0.521 0.120 0.022 -0.071 -0.077 -0.048 0.175 -0.097 -0.240 -0.213
-0.170 0.176 0.546 0.418 0.842 0.506 0.155 0.146 0.146 0.104
0.205 -0.251 -0.148 0.150 1.000 0.219 0.385 0.361 -0.062 -0.064
0.123 0.129 0.184 0.154 0.118 0.156

36 CXERR

0.049 0.051 -0.025 -0.035 -0.003 -0.017 -0.036 0.122 -0.004 -0.059
-0.131 0.018 0.072 0.012 -0.060 -0.116 0.083 -0.063 -0.114 -0.035
-0.120 0.047 0.113 0.594 0.278 0.296 0.163 0.186 0.086 0.055
0.102 -0.057 -0.078 0.087 0.219 1.000 0.078 0.089 -0.005 0.004
0.027 0.049 -0.008 0.070 0.626 0.070

37 SACCLM

0.147 0.155 -0.082 -0.094 0.088 -0.021 -0.275 0.134 0.553 -0.042
-0.071 0.210 -0.207 -0.135 -0.148 0.177 0.018 0.158 -0.364 -0.244
-0.144 0.278 0.073 0.144 0.353 0.105 0.087 0.097 0.034 0.041
0.088 -0.121 -0.066 0.080 0.585 0.076 1.000 0.831 -0.156 -0.074
0.235 0.068 0.172 0.084 0.284 0.042

38 SACCLS

0.145 0.209 -0.048 -0.082 0.074 -0.057 -0.548 0.105 0.584 -0.050
-0.084 0.204 -0.213 -0.098 -0.215 0.150 0.052 0.147 -0.446 -0.323
-0.244 0.525 0.113 0.252 0.581 0.101 0.039 0.118 -0.013 0.074
0.024 -0.080 -0.048 0.045 0.581 0.089 0.831 1.000 -0.257 -0.188
0.275 0.086 0.178 0.022 0.177 0.042

39 DWELLM

-0.035 -0.012 -0.007 -0.089 0.089 0.035 0.128 -0.048 0.045 0.066
-0.010 0.002 -0.064 -0.103 0.105 0.037 -0.082 0.055 0.186 -0.036
-0.074 -0.101 0.012 -0.050 -0.065 0.136 -0.115 -0.051 -0.030 -0.130
0.020 0.140 0.054 -0.088 -0.082 -0.005 -0.158 -0.257 1.000 0.955
-0.712 -0.134 0.165 -0.085 -0.060 -0.070

40 DWELLS

-0.052 -0.035 -0.088 -0.085 0.122 0.081 0.131 -0.043 0.077 0.085
0.004 0.014 -0.085 -0.120 0.108 0.057 -0.094 0.070 0.183 -0.047
-0.085 -0.089 0.002 -0.056 -0.072 0.133 -0.124 -0.057 -0.040 -0.145
0.015 0.155 0.084 -0.103 -0.088 0.004 -0.074 -0.188 0.955 1.000
-0.731 -0.160 0.150 -0.075 -0.040 -0.085

41 FIXRATE

0.125 0.100 0.199 0.165 -0.132 -0.086 -0.193 0.113 -0.084 -0.104
-0.015 -0.013 0.117 0.120 -0.154 -0.055 0.136 -0.087 -0.264 0.054
0.114 0.062 0.058 0.202 0.113 -0.118 0.263 0.184 0.158 0.200
0.020 -0.275 -0.140 0.231 0.123 0.027 0.235 0.275 -0.712 -0.731
1.000 0.376 -0.247 0.180 0.503 0.100

42 BLINKR

0.104 0.096 0.079 0.048 -0.074 -0.059 -0.121 0.105 -0.069 -0.048
-0.128 0.068 0.143 0.009 -0.128 -0.107 0.125 -0.105 -0.111 0.019
-0.122 0.016 0.124 0.209 0.151 0.017 0.227 0.203 0.135 0.237
-0.000 -0.145 -0.191 0.204 0.124 0.049 0.096 0.066 -0.134 -0.160
0.370 1.000 -0.170 0.171 0.484 0.155

43 PUPILD

-0.094 -0.060 -0.571 -0.556 0.540 0.481 -0.549 -0.011 0.557 0.562
-0.543 0.477 -0.456 -0.724 0.533 0.545 -0.043 0.298 0.214 -0.722
-0.130 0.545 -0.076 0.062 0.222 0.028 0.033 0.182 0.063 -0.087
-0.070 0.009 0.281 -0.124 0.104 -0.008 0.172 0.178 0.165 0.180
-0.247 -0.170 1.000 0.056 -0.202 0.009

44 DISC1

-0.023 -0.033 0.042 0.028 -0.023 0.085 -0.119 -0.015 -0.001 0.033
-0.184 0.081 0.072 -0.084 0.058 0.048 0.169 -0.075 0.010 -0.036
0.102 0.026 0.081 0.450 0.283 0.549 0.813 0.271 0.970 0.222
0.057 -0.327 -0.234 0.351 0.154 0.070 0.069 0.022 -0.005 -0.015
0.180 0.171 0.053 1.000 0.211 0.445

45 DISC2

0.041 0.066 0.133 0.140 -0.042 -0.021 -0.175 0.132 -0.086 -0.081
-0.041 0.018 0.115 0.035 -0.040 -0.026 0.133 -0.061 -0.197 0.038
0.134 0.067 0.022 0.144 0.104 -0.116 0.241 0.201 0.167 0.257
0.031 -0.288 -0.197 0.252 0.118 0.026 0.264 0.177 -0.660 -0.646
0.963 0.464 -0.202 0.211 1.000 0.189

46 DISC3

-0.027 -0.036 0.054 0.038 -0.034 0.065 -0.105 -0.021 -0.064 0.021
-0.130 0.048 0.083 -0.008 0.024 0.026 0.172 -0.087 -0.013 -0.013
0.091 0.031 0.057 0.047 0.283 0.556 0.804 0.267 0.967 0.211
0.037 -0.317 -0.229 0.342 0.154 0.070 0.092 0.042 -0.070 -0.085
0.166 0.155 0.009 0.445 0.189 1.000

CORRELATION MATRIX **DECELERATION SEGMENT**

1 EMGARM
1.000 0.978 0.646 0.647 -0.221 -0.089 -0.127 0.157 0.064 -0.095
-0.068 -0.144 -0.158 -0.058 -0.301 0.064 -0.253 0.286 -0.276 -0.124
-0.048 -0.199 0.278 0.072 0.400 0.137 -0.186 -0.140 -0.208 0.129
0.044 0.015 -0.029 -0.027 0.311 0.004 0.151 0.165 -0.074 -0.044
0.155 0.015 -0.141 0.084 0.119 0.094

2 EMGARS
0.978 1.000 0.666 0.667 -0.176 -0.049 -0.134 0.166 0.101 -0.070
-0.069 -0.112 -0.181 -0.064 -0.322 0.081 -0.274 0.308 -0.265 -0.165
-0.103 -0.169 0.253 0.063 0.379 0.124 -0.164 -0.104 -0.218 0.110
0.097 0.023 -0.015 -0.031 0.286 0.021 0.148 0.171 -0.067 -0.044
0.144 0.017 -0.125 0.079 0.104 0.088

3 EMGALM
0.646 0.666 1.000 0.975 -0.213 -0.132 0.035 0.003 -0.098 -0.138
0.172 -0.206 -0.027 0.358 -0.414 -0.092 -0.139 0.117 -0.237 0.258
0.019 -0.320 0.138 -0.103 0.095 -0.003 -0.206 -0.202 -0.203 0.024
0.025 0.012 0.045 -0.058 0.052 -0.083 -0.063 -0.017 -0.041 -0.062
0.086 -0.106 -0.380 0.001 0.031 0.007

4 EMGALS
0.647 0.667 0.975 1.000 -0.199 -0.092 0.027 -0.002 -0.080 -0.114
0.180 -0.222 -0.066 0.275 -0.332 -0.029 -0.173 0.158 -0.197 0.220
0.085 -0.334 0.121 -0.146 0.090 -0.025 -0.240 -0.231 -0.223 -0.004
0.018 0.022 0.055 -0.053 0.046 -0.101 -0.057 -0.029 -0.032 -0.044
0.072 -0.132 -0.333 -0.026 0.029 -0.018

5 RESAMP
-0.221 -0.176 -0.213 -0.199 1.000 0.580 -0.249 -0.151 0.594 0.396
-0.080 0.392 -0.283 -0.372 0.274 0.272 -0.064 0.158 0.146 -0.552
-0.447 0.532 -0.282 0.000 -0.157 -0.054 0.285 0.374 -0.019 -0.258
0.059 0.071 0.172 -0.013 -0.140 -0.020 0.111 0.109 0.072 0.123
-0.142 -0.047 0.535 0.028 -0.107 0.022

6 RESAMS
-0.089 -0.049 -0.132 -0.092 0.580 1.000 -0.020 0.196 0.441 0.455
0.004 0.246 -0.360 -0.479 0.399 0.440 -0.254 0.334 0.362 -0.478
-0.171 0.293 -0.206 -0.076 -0.022 -0.004 0.177 0.194 -0.036 -0.157
0.086 0.003 0.142 -0.025 -0.068 -0.020 -0.044 -0.082 0.016 0.068
-0.094 -0.038 0.404 0.101 -0.051 0.096

7 RESPDM
-0.127 -0.134 0.035 0.027 -0.249 -0.020 1.000 0.491 -0.168 0.019
0.374 -0.221 -0.077 0.261 0.084 0.024 -0.249 0.107 0.309 0.403
0.258 -0.451 -0.128 -0.314 -0.157 -0.121 -0.332 -0.449 -0.116 -0.085
-0.042 0.077 0.093 -0.094 -0.138 0.044 -0.232 -0.281 0.154 0.111
-0.174 -0.113 -0.349 -0.141 -0.150 -0.147

8 RESPDS
0.157 0.166 0.003 -0.002 -0.151 0.196 0.491 1.000 0.082 0.030
-0.015 -0.002 -0.129 -0.131 0.033 0.153 -0.180 0.162 0.044 -0.127
-0.001 -0.029 0.088 0.015 0.155 0.053 -0.079 -0.080 -0.045 0.131
0.040 -0.062 -0.039 0.056 0.083 0.232 0.135 0.119 -0.062 -0.049
0.125 0.108 -0.034 0.038 0.116 0.049

9 ECGRAM
0.060 0.101 -0.098 -0.080 0.594 0.441 -0.168 0.082 1.000 0.504
0.241 0.214 -0.726 -0.531 0.120 0.608 -0.496 0.661 -0.017 -0.700
-0.385 0.524 -0.245 -0.104 -0.030 -0.108 -0.034 0.085 -0.159 -0.147
0.062 0.185 0.280 -0.126 -0.002 -0.033 0.340 0.406 0.017 0.066
-0.088 -0.073 0.571 -0.082 -0.117 -0.086
10 ECGRAS
-0.095 -0.070 -0.138 -0.114 0.396 0.455 0.019 0.030 0.504 1.000
0.135 0.247 -0.370 -0.389 0.308 0.488 -0.307 0.363 0.308 -0.380
-0.121 0.298 -0.197 -0.112 -0.108 -0.087 0.080 0.095 -0.065 -0.133
0.044 0.103 0.195 -0.106 -0.103 -0.003 0.033 -0.008 0.054 0.044
-0.127 -0.062 0.364 -0.014 -0.074 -0.021
11 ECGRDM
-0.068 -0.069 0.172 0.180 -0.080 0.004 0.374 -0.015 0.241 0.135
1.000 -0.121 -0.352 0.184 -0.170 0.242 -0.417 0.406 -0.030 0.261
0.162 -0.187 -0.117 -0.260 -0.151 -0.187 -0.274 -0.324 -0.170 -0.061
0.001 0.143 0.163 -0.149 -0.044 -0.110 0.029 0.040 0.019 0.029
-0.032 -0.128 -0.210 -0.178 -0.056 -0.170
12 ECGRDS
-0.144 -0.112 -0.206 -0.222 0.342 0.246 -0.221 -0.002 0.214 0.247
-0.121 1.000 -0.005 -0.159 0.155 0.105 0.195 -0.150 0.104 -0.325
-0.352 0.395 -0.125 0.158 -0.075 0.035 0.287 0.339 0.069 -0.022
0.062 -0.026 0.009 0.002 -0.096 0.097 0.186 0.167 -0.049 -0.019
0.036 0.050 0.329 0.095 0.050 0.105
13 ECGP/R
-0.158 -0.181 -0.027 -0.066 -0.283 -0.360 -0.077 -0.129 -0.726 -0.370
-0.352 -0.005 1.000 0.498 -0.238 -0.796 0.717 -0.875 -0.208 0.525
0.020 -0.210 0.190 0.280 -0.017 0.113 0.273 0.214 0.225 0.217
-0.026 -0.191 -0.332 0.158 -0.033 0.117 -0.221 -0.249 -0.052 -0.098
0.097 0.169 -0.410 0.106 0.112 0.112
14 ECGQ/R
-0.058 -0.064 0.358 0.275 -0.372 -0.479 0.261 -0.131 -0.531 -0.389
0.184 -0.159 0.498 1.000 -0.590 -0.678 0.500 -0.518 -0.296 0.793
-0.028 -0.405 0.069 0.003 -0.149 -0.022 -0.015 -0.111 0.020 0.056
-0.042 0.023 -0.085 -0.036 -0.084 -0.040 -0.144 -0.083 -0.073 -0.133
0.080 0.035 -0.734 -0.046 0.018 -0.030
15 ECGS/R
-0.301 -0.322 -0.414 -0.332 0.274 0.399 0.084 0.033 0.120 0.308
-0.170 0.155 -0.238 -0.590 1.000 0.488 -0.109 0.147 0.652 -0.317
0.348 0.182 -0.209 -0.204 -0.149 -0.040 -0.029 -0.032 0.072 -0.210
-0.075 -0.045 0.092 0.058 -0.121 -0.063 -0.153 -0.243 0.106 0.128
-0.182 -0.150 0.518 -0.025 -0.087 -0.041
16 ECGT/R
0.064 0.081 -0.092 -0.029 0.272 0.440 0.024 0.153 0.608 0.488
0.242 0.105 -0.796 -0.678 0.488 1.000 -0.586 0.771 0.313 -0.577
0.203 0.275 -0.144 -0.219 0.041 -0.060 -0.181 -0.134 -0.117 -0.145
0.040 0.105 0.293 -0.118 0.025 -0.055 0.214 0.168 0.044 0.111
-0.048 -0.151 0.541 -0.023 -0.019 -0.030
17 ECGPIN
-0.253 -0.274 -0.139 -0.173 -0.064 -0.254 -0.249 -0.180 -0.496 -0.307
-0.417 0.195 0.717 0.300 -0.109 -0.586 1.000 -0.748 -0.206 0.288
-0.009 0.104 0.127 0.332 -0.076 0.134 0.410 0.351 0.287 0.158
-0.022 -0.233 -0.286 0.214 -0.034 0.079 -0.086 -0.049 -0.108 -0.133
0.150 0.115 -0.114 0.157 0.154 0.167

18 ECGQIN
0.286 0.308 0.117 0.168 0.158 0.534 0.107 0.162 0.661 0.363
0.406 -0.160 -0.875 -0.518 0.197 0.771 -0.798 1.000 0.143 -0.466
0.060 0.078 -0.121 -0.287 0.073 -0.104 -0.538 -0.292 -0.242 -0.164
0.044 0.157 0.298 -0.146 0.066 -0.092 0.192 0.217 0.043 0.049
-0.061 -0.153 0.314 -0.096 -0.075 -0.102

19 ECGRIN
-0.276 -0.265 -0.237 -0.197 0.146 0.382 0.309 0.044 -0.017 0.308
-0.030 0.104 -0.298 -0.296 0.652 0.313 -0.206 0.143 1.000 -0.165
0.081 -0.014 -0.287 -0.363 -0.200 -0.070 -0.005 -0.049 -0.071 -0.253
-0.037 0.063 0.162 -0.095 -0.193 -0.112 -0.370 -0.434 0.253 0.208
-0.309 -0.131 0.244 -0.016 -0.221 -0.043

20 ECGSIN
-0.124 -0.165 0.258 0.220 -0.532 -0.478 0.403 -0.127 -0.700 -0.380
0.261 -0.325 0.525 0.743 -0.317 -0.577 0.288 -0.466 -0.165 1.000
0.362 -0.591 0.130 -0.048 -0.136 -0.040 -0.094 -0.253 0.060 0.115
-0.060 -0.054 -0.136 0.015 -0.091 -0.047 -0.302 -0.318 -0.006 -0.062
0.031 -0.032 -0.730 -0.052 0.020 -0.044

21 ECGTIN
-0.048 -0.103 0.019 0.085 -0.447 -0.171 0.258 -0.001 -0.385 -0.121
0.162 -0.352 0.020 -0.026 0.348 0.203 -0.009 0.080 0.081 0.362
1.000 -0.358 0.139 -0.140 -0.050 -0.000 -0.243 -0.341 0.157 0.066
-0.101 -0.123 -0.046 0.088 -0.026 -0.069 -0.133 -0.238 -0.066 -0.051
0.113 -0.118 -0.143 -0.029 0.160 -0.022

22 OPINION
-0.199 -0.169 -0.320 -0.334 0.532 0.293 -0.431 -0.029 0.524 0.298
-0.187 0.395 -0.210 -0.405 0.182 0.275 0.104 0.078 -0.014 -0.591
-0.358 1.000 -0.221 0.187 -0.103 0.074 0.348 0.504 0.062 -0.123
-0.000 0.022 0.078 0.054 -0.062 0.109 0.265 0.328 -0.133 -0.095
0.075 0.049 0.590 0.054 0.058 0.052

23 PITCH
0.278 0.253 0.138 0.121 -0.282 -0.206 -0.128 0.088 -0.245 -0.197
-0.117 -0.125 0.190 0.069 -0.209 -0.144 0.127 -0.121 -0.287 0.130
0.139 -0.221 1.000 0.423 0.534 0.281 0.069 0.071 0.299 0.722
0.127 -0.371 -0.405 0.325 0.467 0.134 0.078 0.094 0.018 0.018
0.108 0.147 -0.132 0.229 0.078 0.192

24 ROLL
0.072 0.063 -0.103 -0.146 0.000 -0.076 -0.319 0.015 -0.104 -0.112
-0.260 0.158 0.280 0.003 -0.204 -0.219 0.332 -0.287 -0.303 -0.048
-0.140 0.187 0.423 1.000 0.424 0.425 0.531 0.424 0.389 0.448
0.142 -0.285 -0.321 0.227 0.341 0.412 0.148 0.129 -0.098 -0.076
0.219 0.213 0.048 0.476 0.214 0.473

25 POWER
0.400 0.379 0.095 0.090 -0.157 -0.022 -0.157 0.155 -0.030 -0.108
-0.151 -0.075 -0.017 -0.149 -0.149 0.041 -0.076 0.073 -0.200 -0.136
-0.050 -0.103 0.534 0.424 1.000 0.391 0.095 0.049 0.143 0.473
0.344 -0.111 -0.114 -0.049 0.779 0.222 0.162 0.138 0.032 0.058
0.052 0.087 0.017 0.467 0.047 0.440

26 HEADING
0.137 0.124 -0.003 -0.025 -0.054 -0.004 -0.121 0.053 -0.108 -0.087
-0.187 0.035 0.113 -0.022 -0.040 -0.060 0.134 -0.104 -0.070 -0.040
-0.000 0.074 0.281 0.425 0.391 1.000 0.450 0.164 0.521 0.253
0.158 -0.343 -0.220 0.218 0.231 0.233 0.033 -0.029 -0.000 0.020
0.047 -0.015 0.034 0.826 0.072 0.812

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27 ROLLAC
-0.186 -0.164 -0.206 -0.240 0.285 0.177 -0.332 -0.079 -0.034 0.080
-0.274 0.287 0.273 -0.015 -0.029 -0.181 0.410 -0.338 -0.005 -0.049
-0.243 0.348 0.069 0.531 0.095 0.450 1.000 0.709 0.545 0.156
 0.207 -0.297 -0.207 0.231 0.041 0.191 0.065 0.013 -0.102 -0.042
 0.208 0.184 0.141 0.626 0.230 0.643
28 PITCHAC
-0.140 -0.104 -0.202 -0.231 0.374 0.194 -0.449 -0.080 0.085 0.045
-0.324 0.339 0.214 -0.111 -0.032 -0.134 0.351 -0.242 -0.049 -0.253
-0.391 0.504 0.071 0.424 0.049 0.164 0.709 1.000 0.248 0.117
 0.142 -0.205 -0.218 0.237 0.010 0.184 0.122 0.154 -0.088 -0.095
 0.146 0.203 0.249 0.237 0.129 0.245
29 YAWACC
-0.206 -0.218 -0.203 -0.223 -0.019 -0.036 -0.116 -0.045 -0.159 -0.065
-0.170 0.064 0.225 0.020 0.072 -0.117 0.287 -0.242 -0.071 0.080
 0.157 0.062 0.299 0.389 0.143 0.521 0.545 0.248 1.000 0.251
-0.040 -0.389 -0.340 0.389 0.051 0.186 -0.016 -0.047 -0.023 -0.021
 0.023 -0.016 0.091 0.467 0.042 0.445
30 SPEEDER
 0.129 0.110 0.024 -0.004 -0.238 -0.157 -0.085 0.131 -0.197 -0.133
-0.061 -0.022 0.217 0.056 -0.210 -0.145 0.158 -0.164 -0.253 0.115
 0.066 -0.125 0.722 0.448 0.473 0.253 0.156 0.117 0.251 1.000
 0.137 -0.436 -0.525 0.302 0.394 0.401 0.080 0.082 -0.079 -0.078
 0.193 0.148 -0.111 0.223 0.176 0.206
31 S/PITCH
 0.094 0.097 0.025 0.018 0.059 0.086 -0.042 0.040 0.062 0.044
 0.001 0.062 -0.026 -0.042 -0.075 0.040 -0.022 0.044 -0.037 -0.060
-0.101 -0.000 0.127 0.142 0.344 0.158 0.207 0.142 -0.040 0.137
 1.000 0.141 0.189 -0.267 0.308 0.148 0.093 0.084 0.004 -0.000
 0.039 0.081 0.005 0.358 0.032 0.361
32 S/ROLL
 0.015 0.023 0.012 0.022 0.071 0.003 0.077 -0.062 0.185 0.103
 0.143 -0.026 -0.191 0.023 -0.045 0.105 -0.233 0.157 0.063 -0.054
-0.123 0.022 -0.371 -0.285 -0.111 -0.343 -0.297 -0.205 -0.389 -0.436
 0.141 1.000 0.723 -0.835 -0.015 -0.166 -0.020 0.006 0.107 0.080
-0.148 -0.058 -0.015 -0.394 -0.162 -0.404
33 S/YAW
-0.029 -0.015 0.045 0.055 0.172 0.142 0.093 -0.039 0.280 0.195
 0.163 0.009 -0.332 -0.085 0.092 0.293 -0.286 0.298 0.162 -0.136
-0.046 0.078 -0.405 -0.321 -0.114 -0.220 -0.207 -0.218 -0.340 -0.525
 0.189 0.723 1.000 -0.804 -0.063 -0.298 -0.013 0.011 0.105 0.103
-0.159 -0.175 0.143 -0.010 -0.167 -0.030
34 POWSET
-0.027 -0.031 -0.058 -0.053 -0.013 -0.025 -0.094 0.056 -0.126 -0.106
-0.149 0.002 0.158 -0.036 0.058 -0.118 0.214 -0.146 -0.095 0.015
 0.088 0.054 0.325 0.227 -0.049 0.218 0.231 0.237 0.384 0.302
-0.267 -0.835 -0.804 1.000 -0.139 0.184 0.057 0.050 -0.114 -0.093
 0.129 0.063 0.029 0.068 0.132 0.088

35 ALTERR
0.511 0.286 0.052 0.046 -0.140 -0.068 -0.138 0.083 -0.002 -0.103
-0.094 -0.096 -0.035 -0.084 -0.121 0.025 -0.054 0.066 -0.195 -0.091
-0.026 -0.062 0.467 0.541 0.774 0.231 0.041 0.010 0.051 0.394
0.308 -0.015 -0.063 -0.134 1.000 0.132 0.200 0.165 -0.016 0.023
0.086 0.088 0.019 0.297 0.087 0.286
36 CXERR
0.004 0.021 -0.083 -0.101 -0.020 -0.020 0.044 0.232 -0.033 -0.003
-0.110 0.097 0.117 -0.040 -0.063 -0.055 0.079 -0.092 -0.112 -0.047
-0.069 0.109 0.134 0.412 0.222 0.233 0.191 0.184 0.186 0.401
0.148 -0.168 -0.298 0.184 0.132 1.000 0.110 0.098 -0.056 -0.056
0.106 0.088 0.025 0.159 0.097 0.167
37 SACCLM
0.151 0.148 -0.063 -0.057 0.111 -0.044 -0.232 0.135 0.340 0.033
0.029 0.186 -0.221 -0.144 -0.153 0.214 -0.086 0.192 -0.370 -0.302
-0.133 0.265 0.078 0.148 0.162 0.033 0.065 0.122 -0.016 0.086
0.093 -0.020 -0.015 0.057 0.200 0.110 1.000 0.809 -0.124 0.053
0.235 0.123 0.182 0.036 0.257 0.102
38 SACCLS
0.165 0.171 -0.017 -0.029 0.109 -0.082 -0.281 0.119 0.406 -0.008
0.040 0.167 -0.249 -0.083 -0.243 0.168 -0.099 0.217 -0.434 -0.318
-0.238 0.328 0.094 0.129 0.138 -0.029 0.013 0.154 -0.047 0.082
0.084 0.006 0.011 0.050 0.165 0.098 0.809 1.000 -0.207 -0.141
0.244 0.100 0.189 -0.036 0.075 -0.002
39 DWELLM
-0.074 -0.067 -0.041 -0.032 0.072 0.016 0.154 -0.062 0.017 0.054
0.019 -0.049 -0.052 -0.073 0.106 0.044 -0.108 0.043 0.253 -0.006
-0.066 -0.133 0.018 -0.098 0.032 -0.000 -0.102 -0.088 -0.023 -0.079
0.004 0.107 0.105 -0.114 -0.016 -0.056 -0.124 -0.207 1.000 0.930
-0.773 -0.104 0.122 -0.012 -0.745 -0.116
40 DWELLS
-0.044 -0.044 -0.062 -0.044 0.123 0.068 0.111 -0.049 0.066 0.094
0.029 -0.019 -0.098 -0.133 0.128 0.111 -0.133 0.099 0.208 -0.062
-0.051 -0.095 0.018 -0.076 0.058 0.020 -0.092 -0.095 -0.021 -0.078
-0.000 0.080 0.103 -0.093 0.023 -0.056 0.053 -0.141 0.930 1.000
-0.716 -0.103 0.165 0.015 -0.612 -0.068
41 FIXRATE
0.155 0.144 0.086 0.072 -0.142 -0.099 -0.174 0.125 -0.088 -0.127
-0.032 0.036 0.097 0.080 -0.182 -0.048 0.150 -0.061 -0.309 0.031
0.113 0.075 0.108 0.219 0.052 0.047 0.208 0.146 0.023 0.193
0.039 -0.148 -0.159 0.129 0.086 0.106 0.235 0.244 -0.773 -0.716
1.000 0.290 -0.208 0.095 0.937 0.194
42 BLINKR
0.015 0.017 -0.106 -0.132 -0.047 -0.038 -0.113 0.108 -0.073 -0.062
-0.128 0.050 0.169 0.035 -0.150 -0.151 0.115 -0.153 -0.131 -0.032
-0.118 0.049 0.147 0.213 0.087 -0.015 0.184 0.203 -0.016 0.198
0.081 -0.058 -0.175 0.063 0.088 0.088 0.125 0.100 -0.104 -0.103
0.290 1.000 -0.137 0.015 0.333 0.032
43 PUPILD
-0.141 -0.123 -0.380 -0.333 0.535 0.409 -0.349 -0.059 0.571 0.369
-0.210 0.329 -0.410 -0.734 0.518 0.541 -0.114 0.314 0.248 -0.730
-0.143 0.590 -0.132 0.048 0.017 0.034 0.141 0.249 0.091 -0.111
0.005 -0.015 0.143 0.029 0.019 0.025 0.182 0.189 0.122 0.165
-0.208 -0.137 1.000 0.071 -0.172 0.041

44 DISC1

0.084	0.079	0.001	-0.026	0.028	0.101	-0.141	0.038	-0.082	-0.014
-0.176	0.095	0.106	-0.046	-0.025	-0.023	0.157	-0.096	-0.016	-0.052
-0.029	0.054	0.229	0.476	0.467	0.826	0.626	0.237	0.467	0.223
0.358	-0.394	-0.010	0.068	0.297	0.159	0.036	-0.036	-0.012	0.015
0.095	0.015	0.071	1.000	0.125	0.990				

45 DISC2

0.119	0.104	0.031	0.029	-0.107	-0.031	-0.150	0.116	-0.117	-0.074
-0.056	0.050	0.112	0.018	-0.087	-0.019	0.154	-0.075	-0.221	0.020
0.160	0.056	0.078	0.214	0.047	0.072	0.230	0.129	0.042	0.176
0.032	-0.162	-0.167	0.132	0.087	0.097	0.257	0.075	-0.745	-0.612
0.937	0.333	-0.172	0.125	1.000	0.235				

46 DISC3

0.094	0.088	0.007	-0.018	0.022	0.096	-0.147	0.049	-0.086	-0.021
-0.170	0.105	0.112	-0.030	-0.041	-0.030	0.167	-0.102	-0.043	-0.044
-0.022	0.052	0.192	0.473	0.440	0.812	0.643	0.245	0.445	0.206
0.361	-0.404	-0.030	0.088	0.286	0.167	0.102	-0.002	-0.116	-0.068
0.194	0.032	0.041	0.990	0.235	1.000				

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CORRELATION MATRIX HOVER SEGMENT

1 EMGARM

1.000 0.969 0.580 0.571 -0.287 -0.205 0.029 0.260 0.077 -0.137
-0.094 -0.147 -0.161 -0.169 -0.221 0.086 -0.206 0.280 -0.271 -0.175
-0.051 -0.182 0.378 0.219 0.402 0.270 -0.084 -0.115 -0.027 0.219
0.294 0.039 0.035 0.500 0.354 0.080 0.310 0.330 -0.119 -0.096
0.179 0.066 -0.039 0.072 0.142 0.069

2 EMGARS

0.969 1.000 0.598 0.592 -0.223 -0.146 0.034 0.258 0.114 -0.092
-0.070 -0.086 -0.182 -0.153 -0.239 0.099 -0.219 0.297 -0.240 -0.200
-0.117 -0.153 0.345 0.197 0.372 0.275 -0.051 -0.076 -0.046 0.187
0.265 0.026 0.050 0.258 0.326 0.094 0.284 0.293 -0.104 -0.079
0.152 0.064 -0.046 0.078 0.124 0.076

3 EMGALM

0.580 0.598 1.000 0.983 -0.239 -0.183 0.039 0.143 -0.166 -0.228
0.087 -0.126 0.073 0.397 -0.464 -0.247 -0.013 -0.020 -0.237 0.262
-0.116 -0.348 0.349 0.104 0.368 0.144 -0.008 -0.120 0.015 0.241
0.133 0.037 0.132 0.096 0.273 0.018 -0.055 -0.054 -0.002 -0.029
0.050 0.029 -0.386 0.084 0.025 0.085

4 EMGALS

0.571 0.592 0.983 1.000 -0.221 -0.169 0.035 0.121 -0.179 -0.208
0.096 -0.146 0.074 0.382 -0.422 -0.228 -0.006 -0.014 -0.211 0.277
-0.065 -0.355 0.363 0.089 0.391 0.137 -0.020 -0.132 0.012 0.255
0.125 0.047 0.130 0.080 0.294 0.024 -0.061 -0.075 0.000 -0.022
0.051 0.022 -0.378 0.074 0.034 0.074

5 RESAMP

-0.287 -0.223 -0.239 -0.221 1.000 0.662 -0.169 -0.255 0.557 0.513
0.094 0.295 -0.332 -0.315 0.310 0.333 -0.198 0.236 0.290 -0.422
-0.371 0.381 -0.374 -0.234 -0.277 -0.130 0.059 0.229 -0.232 -0.321
-0.210 -0.061 0.036 -0.229 -0.235 -0.090 -0.155 -0.183 0.197 0.234
-0.299 -0.153 0.418 -0.050 -0.239 -0.040

6 RESAMS

-0.205 -0.146 -0.183 -0.169 0.662 1.000 -0.053 0.063 0.391 0.375
0.017 0.222 -0.305 -0.328 0.302 0.317 -0.186 0.234 0.366 -0.375
-0.268 0.237 -0.242 -0.107 -0.113 -0.036 0.113 0.232 -0.100 -0.161
-0.112 -0.065 0.094 -0.147 -0.095 0.016 -0.142 -0.185 0.097 0.118
-0.146 -0.082 0.310 0.055 -0.091 0.061

7 RESPDM

0.029 0.034 0.039 0.035 -0.169 -0.053 1.000 0.586 -0.062 -0.050
0.134 -0.229 -0.125 0.086 0.024 0.037 -0.208 0.147 0.137 0.160
0.142 -0.265 -0.038 -0.134 -0.053 -0.052 -0.225 -0.295 -0.092 -0.032
-0.095 -0.050 0.069 -0.151 -0.043 0.062 -0.021 -0.108 0.050 0.037
-0.064 -0.041 -0.214 -0.009 0.012 -0.012

8 RESPDS

0.260 0.258 0.143 0.121 -0.255 0.063 0.586 1.000 0.055 -0.046
-0.050 -0.062 -0.110 -0.053 -0.080 0.050 -0.171 0.149 -0.004 -0.049
-0.080 -0.072 0.123 0.087 0.175 0.126 -0.104 -0.073 -0.024 0.118
0.120 0.077 0.020 0.126 0.165 0.136 0.215 0.167 -0.061 -0.058
0.094 0.040 -0.082 0.010 0.088 0.005

9 ECGRAM
0.077 0.114 -0.166 -0.179 0.557 0.391 -0.062 0.055 1.000 0.567
0.283 0.199 -0.732 -0.521 0.094 0.672 -0.514 0.675 -0.034 -0.673
-0.377 0.520 -0.219 -0.136 -0.134 -0.053 -0.173 0.076 -0.265 -0.259
0.046 -0.028 0.038 0.059 -0.086 -0.019 0.192 0.218 0.054 0.118
-0.189 -0.129 0.604 -0.034 -0.165 -0.023

10 ECGRAS
-0.137 -0.092 -0.228 -0.208 0.513 0.375 -0.030 -0.046 0.567 1.000
0.183 0.210 -0.437 -0.410 0.300 0.527 -0.341 0.432 0.266 -0.357
-0.152 0.292 -0.291 -0.227 -0.212 -0.125 -0.051 0.064 -0.195 -0.254
-0.137 -0.065 0.065 -0.180 -0.196 -0.038 -0.042 -0.164 0.045 0.047
-0.143 -0.047 0.382 -0.011 -0.057 -0.007

11 ECGRDM
-0.094 -0.070 0.087 0.096 0.094 0.017 0.134 -0.050 0.283 0.183
1.000 -0.196 -0.434 0.168 -0.170 0.230 -0.464 0.438 -0.029 0.242
0.153 -0.190 -0.165 -0.368 -0.186 -0.226 -0.361 -0.335 -0.235 -0.173
-0.148 0.013 0.041 -0.204 -0.155 -0.144 -0.078 -0.146 0.068 0.090
-0.124 -0.072 -0.151 -0.141 -0.083 -0.138

12 ECGRDS
-0.147 -0.088 -0.126 -0.146 0.295 0.222 -0.229 -0.062 0.199 0.210
-0.196 1.000 0.011 -0.088 0.037 0.052 0.181 -0.142 0.071 -0.371
-0.459 0.409 -0.182 0.097 -0.111 0.036 0.304 0.394 -0.037 -0.125
0.024 -0.063 -0.000 0.013 -0.061 0.052 0.130 0.163 -0.092 -0.056
0.057 0.112 0.282 0.066 0.070 0.060

13 ECGP/R
-0.161 -0.182 0.073 0.074 -0.332 -0.305 -0.125 -0.110 -0.732 -0.437
-0.434 0.011 1.000 0.455 -0.257 -0.811 0.743 -0.885 -0.237 0.451
0.022 -0.178 0.173 0.312 0.126 0.080 0.407 0.268 0.283 0.254
0.019 0.066 -0.128 0.051 0.087 0.097 -0.134 -0.062 -0.085 -0.146
0.216 0.195 -0.432 0.030 0.167 0.015

14 ECGQ/R
-0.164 -0.153 0.397 0.382 -0.315 -0.328 0.086 -0.053 -0.521 -0.410
0.168 -0.088 0.455 1.000 -0.538 -0.680 0.282 -0.499 -0.226 0.744
-0.039 -0.389 0.107 0.007 0.061 0.004 0.076 -0.044 0.090 0.143
-0.075 0.063 0.035 -0.119 0.025 -0.029 -0.210 -0.183 -0.040 -0.048
0.094 0.036 -0.718 -0.017 0.048 -0.025

15 ECGS/R
-0.221 -0.239 -0.464 -0.422 0.310 0.302 0.024 -0.080 0.094 0.300
-0.170 0.037 -0.257 -0.538 1.000 0.456 -0.161 0.220 0.651 -0.228
0.381 0.135 -0.340 -0.282 -0.272 -0.186 -0.159 -0.143 -0.076 -0.275
-0.221 -0.108 -0.014 -0.198 -0.213 -0.133 -0.091 -0.156 0.112 0.135
-0.208 -0.135 0.443 -0.043 -0.142 -0.031

16 ECGT/R
0.086 0.099 -0.247 -0.228 0.333 0.317 0.037 0.050 0.672 0.527
0.230 0.052 -0.811 -0.680 0.456 1.000 -0.586 0.742 0.266 -0.563
0.116 0.338 -0.232 -0.264 -0.170 -0.061 -0.283 -0.130 -0.211 -0.276
-0.014 -0.130 0.106 -0.010 -0.126 -0.079 0.194 0.123 0.023 0.105
-0.114 -0.186 0.610 0.030 -0.052 0.038

17 ECGPIN
-0.206 -0.219 -0.013 -0.006 -0.198 -0.186 -0.208 -0.171 -0.514 -0.341
-0.464 0.181 0.743 0.282 -0.161 -0.586 1.000 -0.773 -0.220 0.249
0.015 0.057 0.130 0.337 0.077 0.074 0.454 0.369 0.314 0.203
0.073 0.030 -0.129 0.114 0.053 0.106 -0.071 -0.012 -0.101 -0.135
0.209 0.179 -0.154 0.065 0.174 0.053

18 ECGQIN
0.280 0.247 -0.020 -0.014 0.256 0.234 0.147 0.149 0.675 0.432
0.458 -0.142 -0.885 -0.499 0.220 0.792 -0.773 1.000 0.161 -0.402
0.055 0.099 -0.127 -0.286 -0.077 -0.058 -0.421 -0.313 -0.263 -0.209
-0.001 -0.045 0.145 -0.038 -0.044 -0.077 0.163 0.090 0.050 0.113
-0.144 -0.142 0.361 -0.023 -0.090 -0.013

19 ECGRIN
-0.271 -0.240 -0.257 -0.211 0.290 0.366 0.137 -0.004 -0.039 0.286
-0.029 0.071 -0.237 -0.226 0.651 0.266 -0.220 0.161 1.000 -0.079
0.068 -0.025 -0.306 -0.338 -0.226 -0.149 -0.076 -0.081 -0.161 -0.239
-0.551 -0.075 0.096 -0.397 -0.232 -0.134 -0.306 -0.393 0.194 0.195
-0.247 -0.110 0.159 -0.047 -0.216 -0.034

20 ECGSIN
-0.175 -0.200 0.262 0.277 -0.422 -0.375 0.160 -0.049 -0.673 -0.357
0.292 -0.371 0.451 0.744 -0.228 -0.563 0.249 -0.402 -0.079 1.000
0.451 -0.617 0.103 -0.078 0.002 -0.123 -0.038 -0.300 0.155 0.165
-0.136 0.055 0.020 -0.195 -0.032 -0.072 -0.295 -0.370 0.031 -0.028
0.060 0.033 -0.726 -0.047 0.062 -0.052

21 ECGTIN
-0.051 -0.117 -0.116 -0.065 -0.571 -0.268 0.142 -0.080 -0.377 -0.152
0.155 -0.459 0.022 -0.039 0.381 0.116 0.015 0.054 0.068 0.431
1.000 -0.341 0.014 -0.128 -0.104 -0.171 -0.248 -0.440 0.174 0.014
-0.058 -0.040 -0.034 -0.037 -0.088 -0.096 -0.054 -0.162 -0.064 -0.070
0.128 -0.068 -0.134 -0.024 0.160 -0.028

22 OPINION
-0.182 -0.153 -0.348 -0.355 0.381 0.237 -0.265 -0.072 0.520 0.292
-0.190 0.409 -0.178 -0.389 0.135 0.338 0.057 0.049 -0.025 -0.617
-0.341 1.000 -0.242 0.118 -0.187 0.153 0.257 0.525 -0.024 -0.214
0.046 -0.017 -0.128 0.205 -0.138 0.090 0.172 0.271 -0.126 -0.080
0.029 -0.010 0.592 0.001 0.022 -0.006

23 PITCH
0.378 0.345 0.349 0.363 -0.374 -0.242 -0.034 0.123 -0.219 -0.291
-0.165 -0.182 0.173 0.107 -0.340 -0.232 0.130 -0.127 -0.306 0.103
0.014 -0.242 1.000 0.501 0.688 0.245 0.068 0.077 0.264 0.726
0.447 0.118 0.136 0.376 0.526 0.206 0.109 0.149 0.066 0.042
0.080 0.154 -0.149 0.162 0.030 0.170

24 ROLL
0.219 0.147 0.104 0.089 -0.239 -0.107 -0.139 0.087 -0.136 -0.227
-0.368 0.097 0.512 0.007 -0.282 -0.264 0.337 -0.286 -0.338 -0.078
-0.128 0.118 0.501 1.000 0.511 0.444 0.530 0.465 0.484 0.485
0.371 0.049 0.049 0.375 0.415 0.351 0.182 0.201 -0.131 -0.136
0.205 0.143 0.031 0.311 0.180 0.309

25 POWER
0.402 0.472 0.368 0.391 -0.277 -0.113 -0.053 0.175 -0.134 -0.212
-0.186 -0.111 0.126 0.061 -0.272 -0.170 0.077 -0.077 -0.226 0.002
-0.104 -0.187 0.688 0.511 1.000 0.323 0.177 0.153 0.288 0.748
0.541 0.087 0.196 0.419 0.674 0.292 0.162 0.184 0.013 -0.006
0.102 0.127 -0.098 0.301 0.060 0.303

26 HEADING
0.270 0.275 0.144 0.137 -0.130 -0.036 -0.052 0.126 -0.053 -0.125
-0.226 0.036 0.080 0.004 -0.186 -0.061 0.074 -0.054 -0.149 -0.123
-0.171 0.153 0.245 0.444 0.323 1.000 0.360 0.274 0.448 0.264
0.239 0.160 -0.077 0.278 0.247 0.248 0.239 0.177 -0.152 -0.121
0.208 0.045 -0.024 0.105 0.219 0.101

27 ROLLAC
-0.084 -0.051 -0.008 -0.020 0.054 0.113 -0.225 -0.104 -0.175 -0.051
-0.361 0.304 0.407 0.076 -0.159 -0.283 0.454 -0.421 -0.076 -0.038
-0.248 0.257 0.068 0.530 0.177 0.360 1.000 0.738 0.526 0.194
0.155 -0.116 -0.011 0.179 0.129 0.278 -0.012 -0.006 -0.157 -0.151
0.263 0.201 -0.018 0.341 0.269 0.326
28 PITCHAC
-0.115 -0.076 -0.120 -0.132 0.229 0.232 -0.295 -0.073 0.076 0.084
-0.335 0.394 0.268 -0.094 -0.143 -0.130 0.369 -0.313 -0.081 -0.300
-0.440 0.525 0.077 0.465 0.153 0.274 0.736 1.000 0.238 0.144
0.207 0.027 -0.090 0.249 0.104 0.250 0.062 0.133 -0.107 -0.069
0.172 0.199 0.213 0.164 0.160 0.151
29 YAWACC
-0.027 -0.046 0.015 0.012 -0.232 -0.100 -0.092 -0.024 -0.265 -0.145
-0.233 -0.037 0.283 0.090 -0.076 -0.211 0.319 -0.263 -0.161 0.155
0.174 -0.024 0.264 0.454 0.288 0.448 0.526 0.238 1.000 0.290
0.230 0.072 -0.137 0.277 0.216 0.252 0.039 0.017 -0.063 -0.071
0.096 0.043 -0.056 0.217 0.096 0.224
30 SPEEDER
0.219 0.187 0.241 0.255 -0.321 -0.161 -0.032 0.118 -0.254 -0.258
-0.173 -0.125 0.254 0.143 -0.275 -0.276 0.203 -0.209 -0.234 0.165
0.014 -0.214 0.726 0.465 0.748 0.264 0.194 0.144 0.290 1.000
0.586 0.252 0.133 0.348 0.694 0.345 0.067 0.113 -0.026 -0.052
0.170 0.166 -0.143 0.151 0.128 0.151
31 S/PITCH
0.294 0.265 0.133 0.125 -0.210 -0.112 -0.095 0.120 0.046 -0.137
-0.148 0.024 0.019 -0.075 -0.221 -0.014 0.073 -0.001 -0.331 -0.136
-0.058 0.096 0.447 0.371 0.541 0.239 0.155 0.207 0.230 0.586
1.000 0.321 -0.110 0.751 0.606 0.307 0.316 0.389 -0.157 -0.146
0.279 0.153 0.049 -0.015 0.218 -0.018
32 S/ROLL
0.059 0.026 0.037 0.047 -0.061 -0.065 -0.030 0.077 -0.028 -0.085
0.013 -0.063 0.066 0.063 -0.108 -0.130 0.030 -0.045 -0.075 0.055
-0.040 -0.017 0.118 0.049 0.067 0.160 -0.116 0.027 0.072 0.252
0.321 1.000 -0.550 0.152 0.103 0.075 0.072 0.105 -0.021 -0.025
0.016 0.057 -0.086 -0.832 -0.006 -0.830
33 S/YAW
0.035 0.050 0.132 0.130 0.036 0.094 0.069 0.020 0.038 0.065
0.041 -0.000 -0.128 0.035 -0.014 0.106 -0.129 0.145 0.096 0.020
-0.034 -0.126 0.136 0.049 0.196 -0.077 -0.011 -0.090 -0.137 0.133
-0.110 -0.550 1.000 -0.340 0.122 -0.025 -0.116 -0.171 0.125 0.123
-0.075 -0.041 0.004 0.740 -0.050 0.744
34 POWSET
0.300 0.258 0.096 0.080 -0.229 -0.147 -0.151 0.126 0.059 -0.180
-0.204 0.013 0.051 -0.119 -0.198 -0.010 0.114 -0.038 -0.397 -0.145
-0.037 0.205 0.376 0.375 0.419 0.276 0.179 0.249 0.277 0.348
0.751 0.152 -0.340 1.000 0.435 0.171 0.563 0.456 -0.246 -0.241
0.315 0.118 0.097 0.036 0.244 0.050
35 ALTERR
0.354 0.326 0.273 0.294 -0.235 -0.095 -0.043 0.165 -0.086 -0.196
-0.155 -0.061 0.087 0.025 -0.213 -0.128 0.053 -0.048 -0.232 -0.032
-0.088 -0.138 0.526 0.415 0.874 0.247 0.129 0.104 0.216 0.694
0.606 0.103 0.122 0.435 1.000 0.384 0.221 0.270 -0.042 -0.051
0.144 0.129 -0.075 0.244 0.089 0.244

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56 CXERR
0.080 0.094 0.018 0.024 -0.090 0.016 0.062 0.136 -0.019 -0.038
-0.144 0.052 0.097 -0.029 -0.133 -0.079 0.108 -0.077 -0.134 -0.072
-0.096 0.090 0.206 0.351 0.292 0.244 0.278 0.250 0.232 0.395
0.307 0.075 -0.025 0.171 0.384 1.000 0.117 0.132 -0.094 -0.064
0.188 0.096 0.000 0.197 0.170 0.188
57 SACCLM
0.310 0.284 -0.055 -0.061 -0.155 -0.142 -0.021 0.215 0.192 -0.092
-0.078 0.130 -0.134 -0.210 -0.091 0.194 -0.071 0.163 -0.506 -0.295
-0.054 0.172 0.109 0.182 0.162 0.239 -0.012 0.062 0.039 0.087
0.316 0.072 -0.116 0.363 0.221 0.117 1.000 0.805 -0.129 0.033
0.216 0.071 0.212 -0.000 0.261 -0.014
58 SACCLS
0.330 0.293 -0.054 -0.075 -0.183 -0.185 -0.108 0.167 0.218 -0.164
-0.146 0.163 -0.082 -0.183 -0.156 0.123 -0.012 0.090 -0.393 -0.370
-0.162 0.271 0.149 0.201 0.184 0.177 -0.006 0.133 0.017 0.113
0.389 0.105 -0.171 0.458 0.270 0.132 0.805 1.000 -0.258 -0.184
0.298 0.079 0.214 -0.033 0.166 -0.045
59 DWELLM
-0.119 -0.104 -0.002 0.000 0.197 0.097 0.050 -0.081 0.054 0.045
0.068 -0.092 -0.085 -0.040 0.112 0.023 -0.101 0.056 0.194 0.031
-0.064 -0.126 0.066 -0.131 0.013 -0.152 -0.157 -0.107 -0.063 -0.026
-0.157 -0.021 0.125 -0.246 -0.042 -0.094 -0.129 -0.258 1.000 0.933
-0.745 -0.075 0.132 -0.016 -0.739 0.007
60 DWELLS
-0.096 -0.079 -0.029 -0.022 0.234 0.118 0.037 -0.058 0.118 0.097
0.090 -0.056 -0.146 -0.098 0.135 0.103 -0.135 0.113 0.195 -0.028
-0.070 -0.080 0.042 -0.136 -0.006 -0.121 -0.151 -0.089 -0.071 -0.052
-0.146 -0.025 0.123 -0.241 -0.051 -0.084 0.033 -0.184 0.933 1.000
-0.708 -0.072 0.192 -0.015 -0.621 0.006
61 FIXRATE
0.179 0.152 0.050 0.051 -0.299 -0.146 -0.004 0.093 -0.189 -0.143
-0.124 0.057 0.216 0.094 -0.208 -0.114 0.209 -0.144 -0.247 0.060
0.128 0.029 0.080 0.205 0.102 0.208 0.263 0.172 0.096 0.170
0.279 0.016 -0.075 0.315 0.144 0.188 0.216 0.298 -0.745 -0.708
1.000 0.272 -0.238 0.085 0.942 0.029
62 BLINKR
0.066 0.064 0.029 0.022 -0.153 -0.082 -0.041 0.040 -0.124 -0.047
-0.072 0.112 0.195 0.036 -0.135 -0.186 0.179 -0.142 -0.110 0.033
-0.068 -0.010 0.154 0.143 0.127 0.045 0.201 0.199 0.043 0.166
0.153 0.057 -0.041 0.118 0.129 0.096 0.071 0.079 -0.075 -0.072
0.272 1.000 -0.204 0.011 0.318 -0.018
63 PUPILD
-0.039 -0.048 -0.386 -0.378 0.418 0.310 -0.214 -0.082 0.604 0.382
-0.151 0.282 -0.432 -0.718 0.443 0.610 -0.154 0.361 0.159 -0.726
-0.134 0.592 -0.149 0.031 -0.048 -0.024 -0.018 0.213 -0.056 -0.163
0.049 -0.086 0.004 0.047 -0.075 0.000 0.212 0.214 0.132 0.192
-0.236 -0.204 1.000 0.051 -0.200 0.069

```
44 DISC1
 0.072  0.078  0.084  0.074 -0.050  0.055 -0.009  0.010 -0.034 -0.011
-0.141  0.066  0.030 -0.017 -0.043  0.030  0.065 -0.023 -0.047 -0.047
-0.024  0.001  0.162  0.311  0.301  0.105  0.341  0.164  0.217  0.151
-0.015 -0.832  0.740  0.036  0.244  0.197 -0.000 -0.033 -0.016 -0.015
 0.085  0.011  0.051  1.000  0.094  0.998
45 DISC2
 0.142  0.124  0.025  0.034 -0.239 -0.091  0.012  0.088 -0.165 -0.057
-0.083  0.070  0.167  0.048 -0.142 -0.052  0.174 -0.090 -0.216  0.062
 0.160  0.022  0.030  0.180  0.060  0.219  0.269  0.160  0.096  0.128
 0.218 -0.006 -0.050  0.244  0.089  0.170  0.261  0.166 -0.734 -0.621
 0.942  0.318 -0.200  0.094  1.000  0.041
46 DISC3
 0.069  0.076  0.085  0.074 -0.040  0.061 -0.012  0.005 -0.023 -0.007
-0.138  0.060  0.015 -0.025 -0.031  0.038  0.053 -0.013 -0.034 -0.052
-0.028 -0.006  0.170  0.309  0.303  0.101  0.326  0.151  0.224  0.151
-0.018 -0.830  0.744  0.030  0.244  0.188 -0.014 -0.045  0.007  0.005
 0.029 -0.018  0.069  0.998  0.041  1.000
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APPENDIX C

GRAND MEANS

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Table C-1. Means of Main Effects for Physiological Measures in Approach Segment

MEASURE	MOTION		WIND			DISPLAY		
	NO	YES	0/0	8/4	16/8	GRAPH I	GRAPH II	F-DIR
EMGARM	15.485	17.653	16.360	16.189	17.158	15.972	17.555	16.180
EMGARS	10.770	11.974	11.222	11.058	11.836	10.885	12.068	11.162
EMGALR	10.264	11.712	10.266	10.673	12.024	11.006	11.817	10.141
EMGALS	7.817	8.887	7.841	8.122	9.094	8.354	8.788	7.914
RESAMP	141.452	150.685	148.253	143.995	145.959	145.673	144.435	148.098
RESAMS	23.926	27.449	23.127	26.555	27.382	26.016	24.261	26.787
RESPDM	2.637	2.507	2.607	2.588	2.521	2.607	5.533	2.576
RESPDS	0.274	0.334	0.298	0.332	0.283	0.322	0.287	0.303
ECGRAM	242.986	245.217	246.037	243.311	242.957	243.836	244.054	244.416
ECGRAS	19.081	21.357	19.649	20.696	20.314	19.658	22.021	18.980
ECGRDM	0.716	0.699	0.720	0.705	0.697	0.710	0.703	0.710
ECGRDS	0.084	0.087	0.082	0.087	0.088	0.082	0.088	0.087
ECGP/R	0.010	0.017	0.013	0.015	0.014	0.013	0.014	0.014
ECGQ/R	-0.146	-0.149	-0.148	-0.147	-0.147	-0.146	-0.147	-0.148
ECGS/R	-0.173	-0.179	-0.174	-0.176	-0.178	-0.176	-0.176	-0.176
ECGT/R	0.151	0.145	0.145	0.147	0.151	0.149	0.149	0.146
ECGPIN	0.048	0.061	0.045	0.057	0.061	0.052	0.053	0.058
ECGQIN	0.184	0.179	0.186	0.179	0.181	0.181	0.179	0.184
ECGRIN	0.039	0.038	0.039	0.039	0.038	0.039	0.039	0.039
ECGSIN	0.147	0.144	0.148	0.145	0.144	0.146	0.146	0.145
ECGTIN	0.129	0.126	0.127	0.128	0.127	0.128	0.125	0.128

Table C-2. Means of Main Effects for Physiological Measures in Deceleration Segment

MEASURE	MOTION		WIND			DISPLAY		
	NO	YES	0/0	8/4	16/8	GRAPH I	GRAPH II	F-DIR
EMGARM	16.895	20.014	17.725	18.281	19.359	17.688	19.093	18.583
EMGARS	11.443	13.619	11.962	12.469	13.162	12.020	12.945	12.627
EMGALR	14.061	15.997	14.520	15.122	15.444	15.089	15.777	14.220
EMGALS	10.939	12.251	11.411	11.683	11.691	11.678	11.984	11.123
RESAMP	138.475	143.563	141.639	138.609	142.809	139.550	140.004	143.504
RESAMS	23.355	26.580	22.833	25.342	26.729	25.578	23.788	25.547
RESPDM	2.551	2.420	2.521	2.499	2.436	2.507	2.461	2.487
RESPDS	0.241	0.291	0.242	0.276	0.280	0.278	0.262	0.258
ECGRAM	243.579	246.334	247.039	244.822	243.010	244.805	245.562	244.504
ECGRAS	19.897	21.961	18.957	22.164	21.566	20.581	20.507	21.699
ECGRDM	0.702	0.691	0.707	0.694	0.688	0.698	0.693	0.698
ECGRDS	0.088	0.093	0.085	0.094	0.093	0.087	0.091	0.093
ECGP/R	0.011	0.015	0.012	0.014	0.014	0.013	0.014	0.012
ECGQ/R	-0.146	-0.151	-0.148	-0.147	-0.151	-0.148	-0.149	-0.150
ECGS/R	-0.173	-0.181	-0.175	-0.176	-0.179	-0.176	-0.178	-0.176
ECGT/R	0.152	0.147	0.147	0.149	0.152	0.148	0.151	0.150
ECGPIN	0.053	0.062	0.051	0.060	0.062	0.057	0.057	0.059
ECGQIN	0.182	0.182	0.183	0.180	0.182	0.183	0.181	0.181
ECGRIN	0.039	0.038	0.039	0.039	0.039	0.039	0.039	0.039
ECGSIN	0.146	0.142	0.145	0.144	0.143	0.144	0.144	0.143
ECGTIN	0.128	0.125	0.126	0.126	0.126	0.127	0.125	0.127

Table C-3. Means of Main Effects for Physiological Measures in Hover Segment

MEASURE	MOTION		WIND			DISPLAY		
	NO	YES	0/0	8/4	16/8	GRAPH I	GRAPH II	F-DIR
ENGARM	17.018	20.071	17.833	18.285	19.516	17.939	19.175	18.519
EMGARS	11.519	13.920	12.144	12.463	13.553	12.172	13.217	12.771
EMGALR	13.861	15.209	13.656	14.597	15.353	14.589	15.743	13.274
EMGALS	9.806	10.849	9.693	10.361	10.930	10.266	11.327	9.390
RESAMP	141.059	140.591	142.384	139.788	140.304	140.632	139.365	142.479
RESAMS	23.027	24.191	22.421	23.040	25.367	24.756	23.071	23.001
RESPDM	2.606	2.563	2.598	2.615	2.541	2.622	2.548	2.543
RESPDS	0.249	0.335	0.281	0.322	0.273	0.285	0.312	0.279
ECGRAM	245.094	246.864	247.442	245.726	244.771	245.142	246.906	245.889
ECGRAS	20.366	23.290	20.957	22.576	21.952	21.559	20.797	23.129
ECGRDM	0.705	0.697	0.713	0.698	0.693	0.707	0.696	0.701
ECGRDS	0.086	0.103	0.089	0.097	0.098	0.093	0.095	0.095
ECGP/R	0.006	0.012	0.008	0.009	0.008	0.008	0.008	0.009
ECGQ/R	-0.146	-0.151	-0.148	-0.147	-0.151	-0.147	-0.151	-0.148
ECGS/R	-0.171	-0.183	-0.174	-0.178	-0.180	-0.177	-0.178	-0.176
ECGT/R	0.157	0.151	0.151	0.154	0.157	0.153	0.154	0.154
ECGPIN	0.046	0.062	0.047	0.059	0.056	0.049	0.056	0.057
ECGQIN	0.187	0.181	0.186	0.181	0.185	0.185	0.183	0.184
ECGRIN	0.039	0.038	0.039	0.039	0.039	0.039	0.039	0.039
ECGSIN	0.143	0.141	0.143	0.141	0.140	0.142	0.141	0.142
ECGTIN	0.130	0.124	0.128	0.126	0.126	0.128	0.126	0.127

Table C-4. Means of Main Effects For Flight Performance Measures in Approach Segment

MEASURE	MOTION		WIND			DISPLAY		
	NO	YES	0/0	8/4	16/8	GRAPH I	GRAPH II	F-DIR
PITCH	0.096	0.088	0.091	0.084	0.100	0.097	0.107	0.072
ROLL	0.161	0.184	0.137	0.161	0.218	0.150	0.191	0.176
POWER	0.335	0.326	0.285	0.318	0.388	0.342	0.336	0.313
HEADING	0.270	0.207	0.192	0.213	0.310	0.220	0.241	0.254
ROLLAC	3.703	4.279	2.825	3.643	5.505	3.659	3.739	4.574
PITCHAC	1.046	1.448	1.099	1.145	1.497	0.999	1.373	1.368
YAWACC	2.724	2.663	1.432	2.480	4.167	2.635	2.661	2.784
SPEEDER	3.602	5.940	3.913	4.198	6.202	4.877	5.884	3.552
S/PITCH	0.817	0.815	0.815	0.816	0.816	0.817	0.815	0.815
S/ROLL	1.131	1.127	1.133	1.130	1.125	1.128	1.129	1.131
S/YAW	0.739	0.732	0.738	0.736	0.731	0.735	0.734	0.736
POWSET	0.274	0.288	0.271	0.277	0.296	0.283	0.283	0.277
ALTERR	21.561	21.757	18.964	20.682	25.332	23.342	21.262	20.374
CXERR	52.143	53.091	53.032	43.575	61.246	47.040	50.662	60.149

Table C-5. Means of Main Effects for Flight Performance Measures in Decelerated Segment

MEASURE	MOTION		WIND			DISPLAY		
	NO	YES	0/0	8/4	16/8	GRAPH I	GRAPH II	F-DIR
PITCH	0.135	0.129	0.120	0.131	0.144	0.128	0.164	0.103
ROLL	0.167	0.169	0.135	0.164	0.205	0.146	0.176	0.182
POWER	0.153	0.160	0.126	0.141	0.202	0.137	0.201	0.131
HEADING	0.278	0.263	0.254	0.255	0.302	0.179	0.223	0.409
ROLLAC	3.607	4.269	3.417	3.647	4.750	3.450	3.806	4.558
PITCHAC	1.500	1.994	1.571	1.661	2.008	1.404	1.867	1.969
YAWACC	3.662	2.815	2.732	3.107	3.876	2.770	3.183	3.762
SPEEDER	4.986	5.516	4.690	4.572	6.491	4.941	6.837	3.976
S/PITCH	0.674	0.679	0.679	0.673	0.678	0.674	0.680	0.675
S/ROLL	1.000	1.001	1.030	0.999	0.973	0.999	1.002	1.002
S/YAW	0.586	0.583	0.562	0.585	0.606	0.587	0.589	0.577
POWSET	0.505	0.512	0.508	0.508	0.510	0.505	0.509	0.512
ALTERR	8.369	9.424	6.846	7.588	12.257	7.665	12.168	6.858
CXTERR	55.756	105.685	31.626	51.935	158.603	50.739	71.287	120.136

Table C-6. Means of Main Effects for Flight Performance Variables in Hover Segment

MEASURE	MOTION		WIND			DISPLAY		
	NO	YES	0/0	8/4	16/8	GRAPH I	GRAPH II	F-DIR
PITCH	0.114	0.117	0.100	0.110	0.135	0.119	0.134	0.092
ROLL	0.150	0.173	0.118	0.163	0.204	0.146	0.168	0.171
POWER	0.253	0.255	0.194	0.234	0.335	0.243	0.286	0.235
HEADING	0.334	0.298	0.215	0.280	0.453	0.276	0.306	0.366
ROLLAC	3.979	4.688	3.395	4.043	5.562	3.916	4.111	4.972
PITCHAC	1.486	2.103	1.536	1.744	2.105	1.494	1.931	1.960
YAWACC	3.969	3.187	2.669	3.419	4.647	3.447	3.556	3.732
SPEEDER	3.656	4.556	3.417	3.650	5.251	4.046	4.925	3.348
S/PITCH	0.748	0.750	0.746	0.746	0.754	0.749	0.749	0.749
S/ROLL	1.131	1.126	1.137	1.129	1.120	1.128	1.130	1.128
S/YAW	0.729	0.720	0.723	0.727	0.724	0.726	0.726	0.723
POWSET	0.333	0.343	0.336	0.337	0.341	0.338	0.332	0.344
ALTERR	17.874	19.850	13.185	16.219	27.184	18.401	21.076	17.112
CXERR	37.749	58.223	28.275	43.206	72.478	30.705	40.102	73.152

Table C-7. Means of Main Effects for Oculometer Measures Across Segments Approach Segment

MEASURE	MOTION		WIND			DISPLAY		
	NO	YES	0/0	8/4	16/8	GRAPH I	GRAPH II	F-DIR
SACCLM	1.498	1.595	1.535	1.516	1.589	1.597	1.361	1.683
SACCLS	1.500	1.608	1.562	1.553	1.548	1.558	1.559	1.546
DWELLM	0.709	0.370	0.559	0.519	0.541	0.444	0.763	0.411
DWELLS	0.686	0.319	0.520	0.462	0.526	0.392	0.734	0.381
FIXRATE	1.909	3.080	2.394	2.488	2.602	2.675	2.081	2.728
BLINKR	0.124	0.409	0.268	0.236	0.295	0.275	0.293	0.231
PUPILD	5.717	5.421	5.504	5.529	5.673	5.547	5.671	5.488

MEASURE	MOTION		WIND			DISPLAY		
	NO	YES	0/0	8/4	16/8	GRAPH I	GRAPH II	F-DIR
SACCLM	1.531	1.663	1.557	1.572	1.662	1.649	1.366	1.776
SACCLS	1.468	1.637	1.526	1.543	1.589	1.578	1.479	1.601
DWELLM	0.732	0.368	0.589	0.529	0.532	0.434	0.789	0.427
DWELLS	0.717	0.310	0.569	0.488	0.483	0.392	0.750	0.399
FIXRATE	1.843	3.089	2.298	2.487	2.614	2.638	2.088	2.673
BLINKR	0.143	0.490	0.243	0.302	0.403	0.315	0.359	0.274
PUPILD	5.671	5.324	5.500	5.444	5.548	5.481	5.623	5.389

MEASURE	MOTION		WIND			DISPLAY		
	NO	YES	0/0	8/4	16/8	GRAPH I	GRAPH II	F-DIR
SACCLM	1.285	1.395	1.341	1.338	1.340	1.384	1.146	1.490
SACCLS	1.146	1.341	1.258	1.278	1.195	1.279	1.193	1.259
DWELLM	0.831	0.439	0.653	0.639	0.613	0.519	0.896	0.489
DWELLS	0.791	0.398	0.609	0.604	0.570	0.475	0.844	0.465
FIXRATE	1.634	2.783	2.132	2.162	2.332	2.360	1.806	2.460
BLINKR	0.112	0.357	0.230	0.242	0.232	0.211	0.301	0.191
PUPILD	5.855	5.482	5.595	5.642	5.769	5.632	5.759	5.615

APPENDIX D

OPINION DATA SCORES

Table D-1. Workload Opinion Raw Scores Across Six Experimental Subjects

Display	Motion Base	S1	S2	S3	S4	S5	S6
GRAPHIC	MOVING	3.0	1.8	4.0	4.0	4.0	7.0
BAN	MOVING	5.0	2.0	6.5	5.0	5.5	8.0
F-DIR	MOVING	4.0	5.8	4.0	4.0	5.5	9.0
GRAPHIC	FIXED	3.0	1.8	4.0	4.0	5.0	7.5
BAN	FIXED	5.0	2.0	6.5	5.0	7.5	8.5
F-DIR	FIXED	3.0	5.3	5.5	6.0	7.5	9.0

REFERENCES

1. Ince, F., Williges, R. C., and Roscoe, S. N., "Aircraft Simulator Motion and the Order of Merit of Flight Attitude and Steering Guidance Displays," Human Factors, Vol. 17, 1975, pp. 390-400.

2. Beringer, D. B., Williges, R. C., Roscoe, S. N., "The Transition of Experienced Pilots to a Frequency Separated Aircraft Attitude Display," Human Factors, Vol. 17(4), 1975, pp. 401-414.

3. Spyker, D. A., Stackhouse, S. P., Khallafalla, A. S., and McLane, R. C., Development of Techniques for Measuring Pilot Workload: NASA CR-1888, Washington, D. C., November 1971.

4. Stackhouse, S. P., "Workload Evaluation of LLNO Display," 7201-3408, Honeywell, Inc., Minneapolis, Minnesota, October 1973.

5. Stackhouse, S. P., "Pilot Workload Assessment," F0289-FR1, Honeywell Inc., Minneapolis, Minnesota, January 1976.

6. Stackhouse, S. P., "Measurement of Pilot Workload in Manual Control Systems," F0389-FR1, Honeywell Inc., Minneapolis, Minnesota, January 1976.

7. Wolf, J. D., "Crew Workload Assessment: Development of a Measure of Operator Workload," AFFDL Final Technical Report TR-78, Wright Patterson Air Force Base, Ohio, 1978.

8. Lebacqz, J. V. and Aiken, E. W., "A Flight Investigation of Control Display and Guidance Requirements for Decelerating, Descending VTOL Instrument. Transitions using the X-22A Variable Stability Aircraft," Proceedings American Helicopter Society, Washington, D. C., 1975.

9. Wolf, J. D. and Barrett, M. F., "IFR Steep-Angle Approach: Effects of Wind, System Data-Rate, and Contingency-Event Variables," JANAIR Report No. 711105, AD 734 702, Arlington, Virginia, December 1971.

10. Matheny, W. G., Dougherty, D. J., and Willis, J. M., "Relative Motion of Elements in Instrument Display," Aerospace Medicine, Vol. 34, 1963, pp. 111-135.

11. Roscoe, S. N. and Williges, R. C., "Motion Relationships in Aircraft Attitude and Guidance Displays: A Flight Experiment," Human Factors, Vol. 17, 1975, pp. 374-387.

12. Simpson, H. M., and Hale, S. M., "Pupillary Changes During a Decision Making Task," Perceptional and Motor Skills, Vol. 29, 1969, pp. 495-498.

13. Bradshaw, J. L., "Load and Pupillary Changes in Continuous Processing Tasks," British Journal of Psychology, Vol. 59, 1968, pp. 265-271.

14. Parrish, R. V., Houck, J. H., Martin, D. J., Jr., Empirical Comparison of a Fixed-Base and a Moving Base Simulation of a Helicopter Engaged in Visually Conducted Slalom Runs: NASA TN D-8424, Langley Research Center, Virginia 1977.

15. Pritchard, F. E., "A Statistical Model of Atmospheric Turbulance and a Review of the Assumptions Necessary for its Use," Proceedings of 17th AAGARD Conference on Stability Control, Part 2, Cambridge, England, September 1966.

16. Krebs, J. J. and Wingert, J. W., Use of the Oculometer in Pilot Workload Measurement: NASA CR-144951, Langley Research Center, Virginia, February 1976.

17. Cooper, G. E. and Harper, R. P., The Use of Pilot Rating in the Evaluation of Aircraft Handling Qualities: NASA TN D-5153, Ames Research Center, Moffitt Field, California, April 1969.

18. Jex, H. R. and Allen R. W., "Research on a New Human Dynamic Response Test Battery," Part II, Psychophysiological Correlates, Proceedings of the 6th Annual NASA-University Converence on Manual Control, Wright Patterson Air Force Base, Ohio, April 1979.

19. Wierwille, W. W. and Williges, R. C., "Survey and Analysis of Operator Workload Techniques," Final Technical Report S-78-101, Naval Air Test Center, Patuxent River, Maryland, September 1978.

20. Kahneman, D., Attention and Effort, Prentice Hall, Inc., Englewood Cliffs, New Jersey 1973.

21. Cooley, W. W. and Lohnes, P. R., Multivariate Procedures for the Behavioral Sciences, John Wiley and Sons, Inc., New York, 1962.

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Final Report

16. Abstract

A methodological approach to measuring workload was investigated for evaluation of new concepts in VTOL aircraft displays. Physiological, visual response, and conventional flight performance measures were recorded for landing approaches performed in the NASA Visual Motion Simulator (VMS). Three displays (two computer graphic and a conventional flight director), three crosswind amplitudes, and two motion base conditions (fixed vs. moving base) were tested in a factorial design.

Multivariate discriminant functions were formed from flight performance and/or visual response variables. The flight performance variable discriminant showed maximum differentiation between crosswind conditions. The visual response measure discriminant maximized differences between fixed vs. motion base conditions and experimental displays.

Physiological variables were used to attempt to predict the discriminant function values for each subject/condition trial. The weights of the physiological variables in these equations showed agreement with previous studies. High muscle tension, light but irregular breathing patterns, and higher heart rate with low amplitude all produced higher scores on this scale and thus represent higher workload levels.

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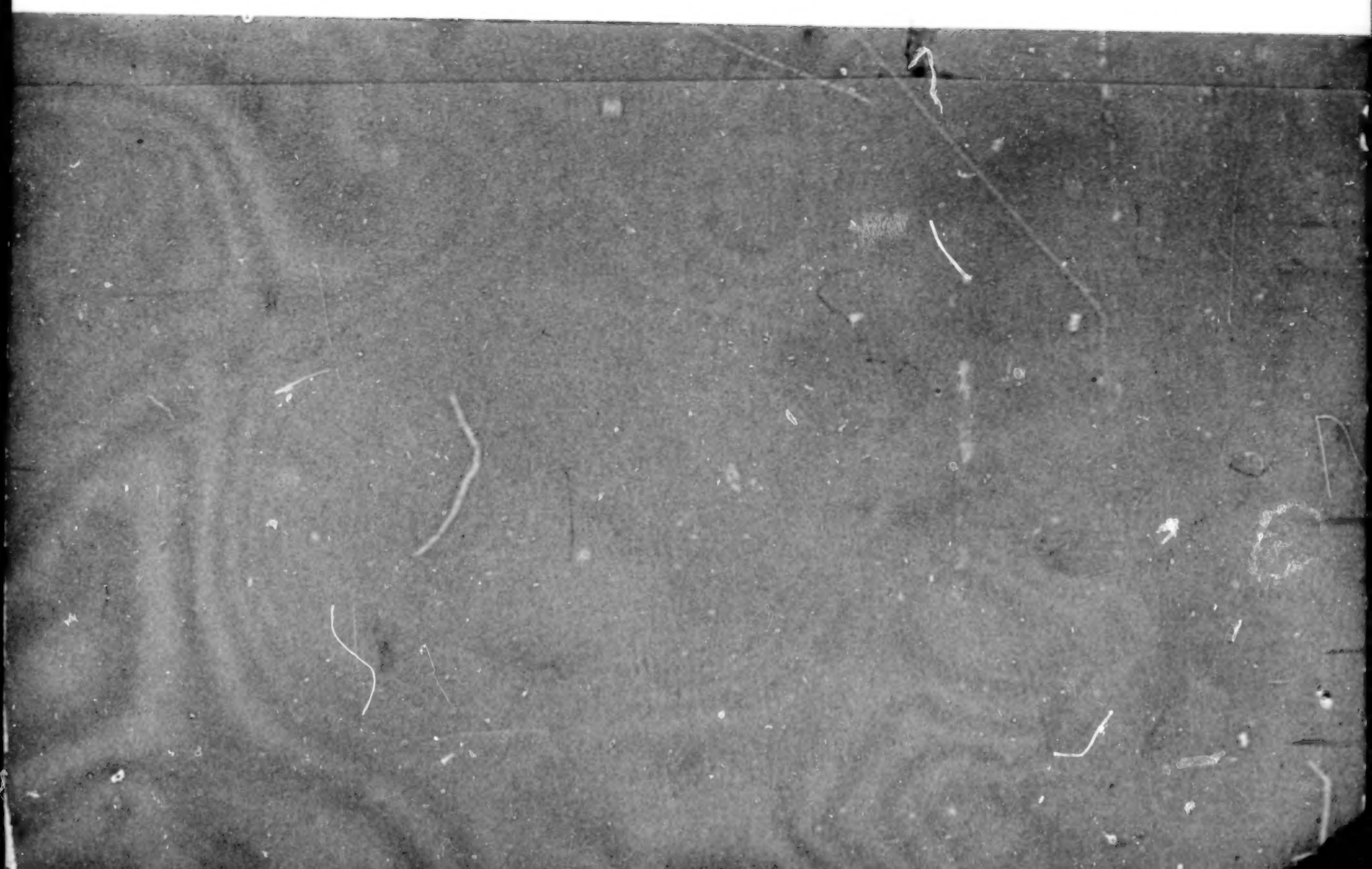

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